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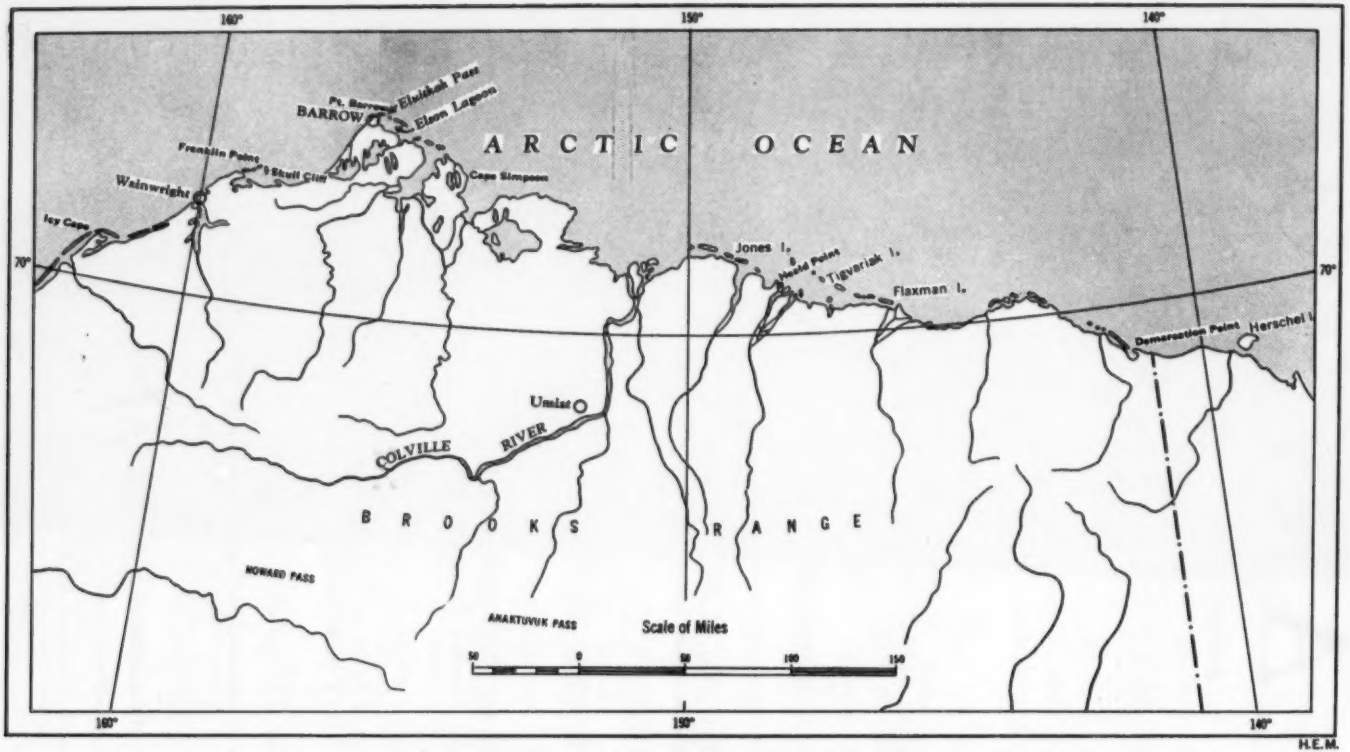

Fig. 1. Sketch map of part of the arctic coast of Alaska.

GLACIAL BOULDERS ON THE ARCTIC COAST OF ALASKA*

Gerald R. MacCarthy†

ALTHOUGH it seems definitely established that the Pleistocene glaciers of Alaska did not extend north beyond the northern foothills of the Brooks Range, except for small tongues that occupied the upper reaches of some of the major river valleys without reaching the coast (Flint, 1947, p. 222), there are scattered references in the literature to glacial boulders found along and close to the shore of the Arctic Ocean (Smith and Mertie, 1930, pp. 241-2; Stefansson, 1910, pp. 460-1; Brooks, 1906, p. 261). The only published comprehensive summary of these scattered observations is that by Leffingwell (1919, pp. 142-9, 175, 177) who, after summing up earlier observations, describes a deposit of till-like material under the name of the "Flaxman formation". His discussion of this formation can be briefly summarized as follows.

At Flaxman Island, the type locality, the formation consists of till composed of clay, boulders, gravel, and sand in proportions similar to those found in other tills. The Flaxman boulders are of many types: quartzites of several kinds, greenstone, granite, limestone, diabase, quartz diabase, and basalt. Petrographic descriptions of three boulders of granite, two of diabase, and one of basalt, are given. Nowhere is the till thicker than 2 or 3 feet. Typical till is mentioned at Flaxman Island and at Heald Point; elsewhere along the coast only scattered boulders are noted. These are described as occurring in localized patches from as far east as Demarcation Point to at least as far west as Barrow, mainly along the coast and rarely as much 1 mile inland. They seem to be confined to altitudes under 25 feet. None of the Flaxman rocks were known from the interior, either in moraines or in place. The till of the inland regions was found to be composed chiefly of sandstone, limestone, and metamorphic rocks, none of which could be identified among the Flaxman boulders. Striations are rare on rock fragments in the inland moraines, but abundant on the boulders along the coast. These various features led to the belief that the boulders of the Flaxman formation have an origin totally different from that of those found in the inland tills.

After considering various possibilities the conclusion was reached that all these scattered boulders, as well as the till at Flaxman Island and Heald Point, represent morainic material left by melting icebergs during a stand

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of the sea somewhat higher than that at present. The further suggestion was made that the glacier producing these bergs probably came down the valley of the Mackenzie River and that the source of the boulders should therefore be sought in the drainage of that river. Though it is not specifically stated, the impression is given that the boulders were more prevalent in the east, diminishing both in numbers and in size toward the west. This would definitely imply that they had been transported from east to west.

Recent observations

While engaged in geothermal work in the Barrow-Cape Simpson area (Figs. 1, 8) during 1949 and 1950 the writer saw several of the boulders mentioned by Leffingwell and many others not noted by him. In all 56 erratic boulders belonging to Leffingwell's Flaxman formation were found near Cape Simpson and Point Barrow on the beaches and on the tundra as far as 8 or 9 miles from shore. Many of them are faceted and bear distinct striae. Included are diabase, granite, quartzite, chert, tonalite, limestone, pegmatite, and an augengneiss. Leffingwell's conclusion that the Flaxman boulders represent berg-rafted debris still appears to be the only logical one and this paper merely extends his observations.

As each boulder was examined rough size measurements were made and chip samples were collected. These samples were turned over to Anna Hietnan of the U.S. Geological Survey who studied the majority in thin sections. Some of the smaller boulders were collected whole and are now exhibited in the library of the Arctic Research Laboratory at Point Barrow. They bear labels giving location, field number, and tentative identification. Several of the field identifications do not agree precisely with later petrographic determinations made from thin sections.

Occurrences of the boulders

Erratic boulders, some of which are faceted and bear distinct striae, were seen near Cape Simpson and near Barrow and were observed by others at Tigvariak Island, Wainwright, and other localities along the coast (Table 1). They are scattered thinly over the tundra and along certain shores, particularly those of sheltered estuaries and lagoons. The tundra boulders do not occur at altitudes above 25 feet, as previously noted by Leffingwell. The shore boulders are, of course, at or very close to present sea-level.

Of the 56 boulders noted at least 10 seem to be well faceted and to bear definite striations. In addition there are five or six others that seem to be definitely striated, although no unmistakable facets have been developed on them. In this latter group several show the supposed striae on more than one face.

Fig. 2. Quartzite cobble (No. 2) from beach at Barrow. Note faceted upper surface.

Shore boulders

Very few boulders were found on the open sea beaches. For example, the 14-mile stretch that extends from Barrow village beyond Point Barrow to Eluitkak Pass was searched carefully several times for erratic boulders, but despite Leffingwell's assertion (1919, p. 146) that "there is a noticeable amount of Flaxman material in the beach wash at Barrow", only one small cobble was found. This beach is composed of rather fine gravel and coarse sand, with hardly any pebbles larger than egg-size. The one cobble that was found was lying on the beach near the Arctic Research Laboratory (Fig. 2). It measures 9 by 5 by 4½ inches, weighs 14 pounds, and is composed of a tough, indurated quartzite (Table 2, No. 2). It has one well developed flat face, which is very suggestive of glacial abrasion. A small number of boulders lying on the beaches at other localities, e.g., Tigvariak Island, Skull Cliff, Wainwright, have been reported, but they are relatively uncommon. Stefansson (1910, pp. 460-1) says "There are boulders at Cape

Table 1. List of glacial boulders found in the Barrow area

Rock type	*Cape Simpson*	*Tigvariak Island*	*Elson Lagoon*	*Imekpuniglu Lagoon*	*Sinnyu Lagoon*	*Ikpili Lagoon*	*Barrow Base*	*Tundra near Barrow*	*Skull Cliff*	*Sea Floor*	*Total*
Diabase	3	1	—	8	2	—	—	1	1	1	17
Granite	—	—	2	6	1	1	—	4	1	1	16
Quartzite	—	—	2	3	2	1	1	—	1	—	10
Chert (or Chalcedony)	—	—	2	1	—	—	—	1	—	—	4
Tonalite	1	—	—	—	1	—	—	1	—	—	3
Limestone	1	—	—	—	1	—	—	—	—	1	3
Pegmatite	—	—	—	—	1	—	—	—	—	—	1
Augengneiss	1	—	—	—	—	—	—	—	—	—	1
Undetermined	—	—	—	—	—	—	—	1	—	—	1
Total	6	1	6	18	8	2	1	8	3	3	56

Fig. 3. Granite boulder (No. 50) nearly buried in tundra swamp. This is the largest boulder seen. The flags mark the approximate dimensions of the upper, exposed surface.

Simpson[1] and at various points between that cape and the Colville. Natives say that there are boulders here and there inland from Point Barrow. True, there are stretches of a mile or two here and there without a stone of noticeable size." It is to be noted that, although he is speaking of boulders *along the coast*, most of those he mentions would here be classified as *tundra boulders*.

The boulders are far more common on the shores of estuaries and lagoons, such as those just east of Barrow village, even of those which are now separated from the ocean by continuous beach barriers, and along the south (landward) shore of Elson Lagoon than on the open-sea beaches. In these sheltered spots are numerous, closely spaced groups of small boulders, as well as isolated specimens of larger size. This grouping strongly suggests that drifting bergs, which entered the sheltered coves, were trapped there, melted at the spot where they first grounded and left a concentration of debris in a small area.

Dredging operations carried out in the shallow waters just off-shore between Barrow village and Point Barrow have brought up a few small boulders and many pebbles, which were also probably ice-rafted. These boulders must have been dropped recently as they have not been buried by sediments.

Tundra boulders

Eighteen of the fifty-six erratics studied were found behind the present beaches, from the tops of the low bluffs directly at the shore to several miles inland. The largest was a piece of granite (No. 50), located well over a mile from shore. It was completely buried in a tundra swamp except for most of its upper surface, which was flush with the ground (Fig. 3). The exposed

[1] None were found on the *beaches* in the Cape Simpson area in 1949-50.

surface measured 5 feet 8 inches by 3 feet 2 inches; by prodding with a thin steel rod the greatest dimensions were found to be about 6 feet 3 inches long, 4 feet 2 inches wide and 2 or 3 feet thick. It must, therefore, weigh at least 4 or 5 tons. The boulder most distant from salt water was a large, light-coloured granite boulder (No. 42), which was estimated as weighing at least a ton. It is about 13.6 miles south 17½ degrees east of Barrow Aero, 11.4 miles inland from the shore to the west and 8.9 miles from the nearest point on Elson Lagoon. It stands 2 or 3 feet above the tundra surface. No other cobbles or boulders were seen farther from the coast line than this, except deposits in the channel bars of the major streams, such as those of the Colville River at Umiat.

All these boulders were accidentally discovered during the course of other work and no particular search was made for additional specimens on the tundra. It is not possible to state at this time whether there is any particular environment in which they are more common than elsewhere. Still, an impression remains that they are most common — certainly the larger ones seem to be — in the ovate swamps, where they should be least easily visible, and less common on the abandoned beach ridges and other "high" ground. If this impression is correct, it might be considered as rather slender evidence in favour of the view that some of these peculiar ovate depressions, both tundra lakes and swamps, are actually kettle holes of a sort, formed by the wasting away of large tabular bergs that had settled into, or been partially buried by, the soft sediments on which they had grounded.

Like the shore boulders, these tundra boulders are fresh and unaltered, so that it is impossible that they could have been lying exposed on the surface for any great length of time, even in the arctic climate. There seems no conceivable way in which they could have reached their present positions other than by being rafted by drifting icebergs during a higher stand of the sea. At the time Leffingwell wrote his paper (1919) relatively little was known of the Canadian Arctic and so the Mackenzie glacier seemed the only logical source of bergs.

When the floating ice islands in the Arctic Ocean were discovered (Koenig *et al.*, 1952) it was thought possible that the boulders had been brought down from the Canadian Arctic Archipelago and not from the Mackenzie River area. However, direct comparison of specimens from T-3 with the Barrow boulders has shown that whereas they are somewhat similar, there are sufficient differences to indicate very definitely that they could not have originated in the same deposit.

Rock species

Of the 56 individual boulders and cobbles noted 16 were granite, 17 were diabase, 10 were quartzite, 4 were chert or chalcedony, 3 were tonalite, 3 were limestone, 1 was pegmatite, 1 was an augengneiss, and 1 was undetermined. Two of the quartzites were somewhat conglomeratic. It should

be noted that the granites and diabase greatly outnumber the quartzites. Leffingwell states (1919, p. 143) that at Flaxman Island "the most conspicuous, both in colour and abundance, are the quartzites." This discrepancy may be purely accidental or, more likely, may be caused by the Flaxman deposit having been brought in by a single large berg that had originated in a locality where quartzite predominated among the morainic materials. The wide spread in the composition of these boulders seems to imply a great diversity of places of origin and this is in itself a very strong argument for the glacial origin of the deposits.

Table 2. Detailed description of the 56 boulders and cobbles recorded in 1949–50

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
		Cape Simpson area	
6	Open tundra near main oil seep. 4½ × 3½ × 1½	Tonalite cobble; rounded corners; one poorly developed flat face.	Intermediate intrusive rock, abundant oligoclase, little or no potash feldspar, considerable quartz; hornblende and biotite in equal amounts; accessories are sphene, magnetite, apatite, allanite, and epidote. Biotite altered to chlorite, which includes rutile. Epidote and sericite are present as alteration products.
7	Flank of highest mound near north seep, about ¼ mile from beach. 78 × 68 × 23	Diabase; angular. (Fig. 4)	Coarse olivine diabase with sparse granophyric quartz and potash feldspar between plagioclase laths; augite main dark constituent; olivine partly altered to iddingsite and serpentine; ilmenite, magnetite, apatite accessories; worm-like inclusions of ilmenite along borders of serpentine aggregates; symplectitic intergrowths of ilmenite and augite; chlorite and serpentine common alteration products after augite.

Fig. 4. Large diabase boulder (No. 7) at Cape Simpson. This is undoubtedly the one mentioned by Leffingwell (1919, p. 146).

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
8	A few feet from No. 2; on tundra surface. 18 × 12 × 10	Sandy dolomitic limestone; fragment of small, lenticular mass.	Sandy limestone; small quartz grains in fine-grained dolomitic matrix; magnetite also occurs.
9A and 9B	Surface of tundra near north seep. 8 × 3 × 1 (8 - 10 lbs.)	One shows obscure striae.	Diabase, no thin sections made.
10[1]	Short distance south of middle seep. "About size of oil drum".	Granite gneiss; a triangular point projecting through tundra.	Gneissic granite of quartz, plagioclase, microcline, and biotite, with large feldspar "augen". Quartz shows strong strain shadows. Inclusions of zircon and allanite in light minerals surrounded by epidote. Many biotites rimmed by small ilmenite scales and epidote grains. Alteration products are chlorite and sericite.
		Tigvariak Island	
43[2]	South beach, 70°10′N. 147°15′W. 66 × 36 × 30	Coarse diabase; rounded; 5 similar specimens seen in bottom of drained pond; also smaller ones on north beach.	*See* No. 7 (Cape Simpson area).
		South shore of Elson Lagoon	
29[3]	Tundra, near triangulation station Brant. 9 × 6 × 5	Chert cobble, grey; no obvious glacial features.	*See* No. 26 (Imekpuniglu Lagoon).
30[3]	Tundra, near first small stream south of triangulation station Brant. 8 × 7 × 5	Chert, brownish cobble.	Contains more large quartz grains and less chalcedony than No. 26; *see* No. 26 (Imekpuniglu Lagoon).
5	Top of bluff near triangulation station Lead, 7½ miles southeast of Arct. Res. Lab. 11 × 4 × 2	Quartzite, angular.	Light reddish and contains few fragments of tourmaline; compare No. 21 (Imekpuniglu Lagoon). G. A. Llano (oral communication) reports similar quartzite from Anaktuvuk Pass.
32	Tundra, 65 feet from water line, south side of estuary, north of triangulation station Lead. 16 × 16 × 24	Granite boulder, no facets or striae, almost completely buried in tundra muck and soft plastic grey clay. (Fig. 5)	Specimen too small to be representative; thin section shows very little potash feldspar but several grains are in fine-grained mosaic between large rounded oligoclase grains. Composition is thus near tonalite. Biotite is only dark constituent. Sphene, allanite, epidote, and zircon are accessories.

[1] Reported by D. S. O'Leary, Arctic Contractors.
[2] Collected by Louis Weeden, Cornell University, Arctic Research Laboratory.
[3] Collected by Owen E. Rye, University of Alaska.

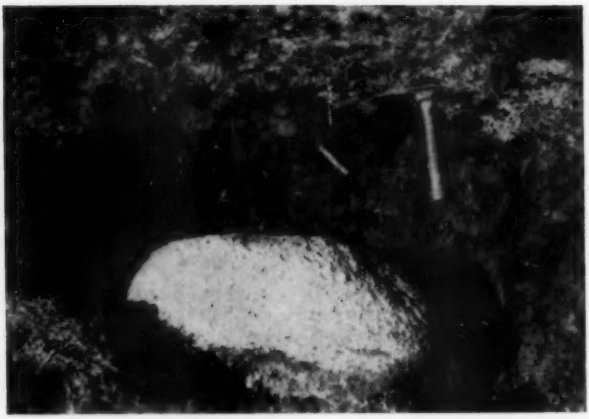

Fig. 5. Granite boulder (No. 32) near Triangulation Station "Lead".

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
33	Inner edge of beach near Avak Bay, ¼ mile south of triangulation station Avak, southeast of Arct. Res. Lab. 22 × 12 × 6	Quartzite, angular wedge-shaped fragment, with sharp corners and edges.	Bioclastic quartzite containing pebbles of chert, chalcedony, and quartzite in addition to rounded quartz grains with overgrowths of quartz; dark red. Like No. 36 (Sinnyu Lagoon).
34	Top of frost mound on tundra, ½ mile south of triangulation station Avak. 21 × 19 × 14	Granite, reddish, subangular boulder; well rounded corners and edges; no striae.	*See* No. 12 (Imekpuniglu Lagoon).
		South shore of Imekpuniglu Lagoon	
11	Tundra on inner edge of lagoon beach. 23 × 15 × 12	Granite, aplitic, one well developed facet and distinct striae; nearly buried.	Aplitic red granite, microcline-rich; gneissic structure; albitic plagioclase present; accessory magnetite. *See* No. 18 (Imekpuniglu Lagoon).
12	Beach, a few feet east of No. 11. 12 × 10 × 8	Granite, reddish cobble, faceted but not striated.	Like Nos. 34 (Elson Lagoon) and 45 (Skull Cliff), is a light reddish medium-grained granite. Equal amounts of quartz, albitic feldspar, and microcline; plagioclase is partly subhedral, partly anhedral. Dark mineral is biotite with zircon inclusions. Biotite altered to chlorite, which includes zircon and rutile; muscovite sparse; sericite is common alteration product.

Fig. 6. Boulder of fine-grained diabase (No. 15), half awash on the beach of Imekpuniglu Lagoon. Note the distinct striae.

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
13	*See* No. 11. 9 × 7 × 4	Quartzite, dark grey, facets and striae.	Like No. 22 (Imekpuniglu Lagoon) contains abundant rounded plagioclase and quartz grains. Matrix is fine- to medium-grained quartz and feldspar. Accessories are chlorite (after biotite) with rutile inclusions, sericite, and magnetite.
14	*See* No. 11. 12 × 10 × 8	Diabase cobble, subangular with suggestions of facets but no striae.	Normal diabase; radiating structure formed by intergrown plagioclase and augite.
15	Half immersed in lagoon near No. 14. 14 × 12 × 8 (weight 108 lbs.)	Diabase, 2 well developed facets, each with 3 directions of cleanly incised striae (Fig. 6).	Fine-grained augite diabase with a few serpentine aggregates after olivine. Augite partly altered to serpentine and chlorite. Ilmenite and magnetite are the ore minerals.
16	5 feet from No. 15. 6 × 4 × 3½	Diabase cobble, no facets or striae.	No thin section made.
17	Near No. 16. 10 × 8 × 6	Suggestion of facets but no striae.	Altered diabase. Plagioclase in part altered to sericite and augite to hornblende, chlorite and serpentine.
18	Near No 17. 8 × 5½ × 5	Suggestion of facets but no striae.	Aplitic red granite. Biotite altered in part to chlorite. (*See* No. 11, Imekpuniglu Lagoon).
19	With No. 18. 5½ × 4½ × 2½	Diabase cobble; two definite facets, each bearing striae.	*See* No. 15.
20	Beach. 9 × 8 ×3½	Diabase, rectangular slab, no striae.	No thin section made.

Field No.	Location and size (inches)	Field Description	Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.
21	*See* No. 20. 7½ × 6 × 4	Quartzite, subangular (well rounded outline broken at one end).	Bioclastic quartzite, reddish; granoblastic overgrowths on original round quartz. Some grains are chalcedony or quartzite. Sericite, biotite, chlorite, and magnetite are scarce.
22	*See* No. 20. 5 × 4 × 3	Quartzite cobble, subangular, no facets or striae.	*See* No. 13 (Imekpuniglu Lagoon).
23	*See* No. 20. 13 × 8 × 6	Granite, subangular, shape indicates it was broken from a larger, well-rounded boulder. No facets or striae. Medium coarse, light yellowish granite.	No thin section made.
24	20 feet east of No. 23. 13 × 7 × 6	Diabase, medium-grained resembling No. 43 (Tigvariak Island).	No thin section made.
25	———— 6 × 5 × 4	Granite, rounded cobble fragment, medium grained. No facets or striae.	Medium-grained, reddish granite, a few chlorite flakes (altered biotite); rutile and magnetite inclusions in chlorite.
26	Tundra, 100 yards inland, 10 or 12 feet above sea-level. 10 × 6 × 6	Chert, angular fragment, broken from large well-rounded boulder.	Fine-grained chalcedony with coarse quartz in vugs and layers.
27	———— 13 × 10 × 5	Granite, fine-grained, pink, gneissic, like No. 3 (Barrow area).	No thin section made.
28	Lagoon beach. 7 × 6 × 6	Diabase cobble, coarse-grained. Visible grains of metallic sulfide (?).	*See* No. 7 (Cape Simpson area).
		Sinnyu Lagoon	
35A	———— 11 × 9 × 4	Limestone, slabby boulder, dark grey, fossiliferous.	Fossiliferous limestone, largely recrystallized along former fossil positions.
36	Inner end of estuary leading back to tundra from lagoon. 9 × 7½ × 5	Quartzite, subangular cobble, greenish.	Contains pebbles of chert, chalcedony, and quartzite. Many of these pebbles are angular. Like No. 33 (Elson Lagoon).
37	*See* No. 36. 8½ × 6½ × 3½	Tonalite, grey, subangular.	Like No. 6 (Cape Simpson).
38	Half-way up east side of lagoon. 24 × 24 × 14	Granite pegmatite.	Granite pegmatite with albitic plagioclase, quartz, and muscovite. Specimen too small to be representative.

Field No.	Location and size (inches)	Field Description	Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.
39A	East side of inlet leading into lagoon. 6 × 6 × 3	Diabase cobble, one distinct facet, no striae.	*See* No. 7 (Cape Simpson).
39B	*See* No. 39A. 11 × 6 × 4½	Diabase cobble, one large and one small moderately developed facet, no striae.	*See* No. 7 (Cape Simpson).
40	Beach, east shore of Lagoon. 18 × 14 × 8	Granite boulder, red. No facets or striae.	Granite, with quartz, oligoclase, and microcline. Accessory apatite and zircon. Nos. 40 and 51 (Barrow area) are darker red than Nos. 12 (Imekpuniglu Lagoon) and 45 (Skull Cliff).
35B	Close to No. 35A. 9 × 8 × 5	Quartzite, rounded cobble, red-banded, no facets or striae.	No thin section made.
		Ikpilin Lagoon	
41A	Eastern shore. 14 × 8 × 6	Granite, aplitic, red cobble, well rounded; no striae. Like No. 11 (Imekpuniglu Lagoon).	*See* No. 11 (Imekpuniglu Lagoon).
41B	Eastern shore. 8½ × 7 × 3	Quartzite boulder, grey, slabby, angular; no striae.	No thin section made.
		Barrow area	
2	Sea beach between Barrow village and tip of spit running southeast from Point Barrow. 9 × 5 × 4½ (weight 14 lbs.)	Quartzite cobble, appears to be glacially polished and striated. (Fig. 2).	Blastoclastic quartzite.
3	Tundra 2½ miles south of Barrow Base. 20 × 14 × 16	Granite boulder; no facets or striae. (Fig. 7).	Fine- to medium-striated, foliated granite, rich in microcline. Square, small dark-brown flakes of biotite contain zircon inclusions with dark, pleochroic haloes.
44	Tundra south of Barrow, 6 miles from coast. 10 × 10 × 9 (weight 54 lbs.)	Chert boulder, vuggy, squarish. Similar to No. 26 (Imekpuniglu Lagoon); no striae.	*See* No. 26 (Imekpuniglu Lagoon).
1	Tundra 4½ miles southeast of Barrow Base. 20 × 19 × 11	Tonalite boulder; roughly rectangular, rounded corners and edges; no striae.	*See* No. 6 (Cape Simpson area).

[4] Collected by Karl VonderAhe, Arctic Contractors.

Fig. 7. Granite boulder (No. 3) on tundra about 2½ miles inland from the Arctic Ocean.

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
48[5]	Crest of low knoll, about 1½ miles southeast of Barrow village. 11 × 8 × 6	Diabase cobble, crudely faceted.	Chip specimen lost; no thin section made.
49[6]	Tundra just south of Imekpuniglu. 6 × 3½ × 2 weight about 3 lbs.)	Igneous or metamorphic rock with network of thin quartz veins; dark-grey, fine-grained.	Chip specimen lost; no thin section made.
50	1¾ miles south of the south shore of Imekpuniglu Lagoon. 75 × 50 × 24 or 36 (partly buried)	Granite, coarse; upper, exposed surface is flat and flush with ground. Largest boulder seen in area. (Fig. 3).	Specimen is too small to be representative. A little potash feldspar (antipertite in plagioclase). No hornblende, only biotite. Accessory magnetite.
51	Tundra, at head of small ravine 1 mile southwest of Barrow village. 15 × 13 × 6½ (weight 63 lbs.)	Granite, slabby; 2 very flat, parallel surfaces, rounded edges and corners, no striae.	Darker red than No. 45 (Skull Cliff) and No. 12 (Imekpuniglu Lagoon). Main minerals as No. 45, but there is less microcline, and the plagioclase is oligoclase. Subhedral forms and weak zoning common in plagioclase. Accessory sphene, epidote, magnetite, and zircon.
42[5]	Near beach of large lake of Barrow. (*See* text, p. 75) ("must weigh about a ton"[4])	Granite boulder, light coloured; no striae; extends 2 to 3 feet above tundra surface.	No sample taken.

[5] Found by B. J. Longeski, United Geophysical Company.
[6] Found by G. S. Scholl, Navy Ordnance Laboratory.

Fig. 8. Sketch map of the Barrow area, showing location of some boulders.

Field No.	*Location and size (inches)*	*Field Description*	*Petrographic Analysis Anna Hietnan, U.S. Geol. Surv., Analyst.*
		Dredged from present sea floor	
31[7]	Barrow Base; from 120-foot depth. 18½ × 10 × 3	Limestone, sandy, dolomitic; angular, lozenge-shaped fragment. 2 large flat surfaces (one barnacle-encrusted), striae on both.	Angular grains of quartz, feldspar, and abundant chalcedony embedded in carbonate matrix. Chlorite, sericite, hematite, and magnetite also.
44A[7]	Off Barrow Base; from 180-foot depth. 11 × 9 × 6 (weight 26 lbs.)	Granite, light pink, fine-grained, subangular cobble; 2 flat faces, one bryozoan-encrusted; no striae seen.	No thin section made.
44B[7]	Off Barrow Base; from 5-foot depth. 7 × 5 × 3	Diabase, small, subrounded cobble; no facets or striae.	No thin section made.
		Skull Cliff area	
46[3]	Tundra, top of bluff along coast 3.3 miles northeast of Skull Cliff. 18 × 13 × 10	Diabase boulder, well rounded, slightly weathered on one surface, thought to be a basalt until thin sections were made.	Fine-grained augite diabase with a few serpentine aggregates after olivine. Ilmenite present. Diabase texture seen in thin section. Small inclusion of sandstone contains subangular grains of quartz, chalcedony, and plagioclase, with isotopic matrix coloured brown by iron oxide.
45	Inner margin of beach, 15 miles southwest of Barrow Base. 26 × 18 × 12	Granite, light reddish, medium-grained, subangular boulder; no facets or striae.	*See* Nos. 34 (Elson Lagoon) and 12 (Imekpuniglu Lagoon).
47	High on beach 8.4 miles northeast of Skull Cliff. 16 × 11 × 4	Quartzite spall, milky-white, evidently broken from a larger boulder recently; no facets or striae.	Quartzite, coarse, white; from a highly metamorphosed area; strongly deformed.

[7] Collected by Dr. George MacGinitie, former Director, Arctic Research Laboratory.

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THE EVOLUTION OF THE FRESHWATER RACES OF THE ATLANTIC SALMON (*SALMO SALAR* L.) IN EASTERN NORTH AMERICA

G. Power*

THE life cycle of the Atlantic salmon (*Salmo salar* L.) is typically divided between freshwater and marine environments. Spawning occurs in rivers and the juvenile salmon, known as parr, remain in this habitat for from 1 to 7 years before changing into smolts and migrating to the sea. Little is known of the marine life of the salmon except that it usually occupies a period of from 1 to 3 years, during which growth is extremely rapid. Following this phase the fish return to the rivers of their origin, attain full sexual maturity, and spawn, thus completing the cycle.

All Atlantic salmon do not conform to this pattern, however, and a number of forms, known as Ouananiche, Sebago salmon, landlocked salmon, etc., are recognized, which complete their life cycle entirely in fresh water. These freshwater races are exceedingly widespread in eastern North America. Jordan and Evermann (1896) recognized two types and, although they were indistinguishable morphologically, listed them as subspecies of the Atlantic salmon, *Salmo salar sebago* and *Salmo salar ouananiche*. Wilder (1947) was unable to find any morphological criterion for separating the Sebago salmon from the Atlantic salmon. The most obvious distinction between the Atlantic salmon and its freshwater races is that the latter do not migrate to sea at any stage in the life cycle, although in many instances they are not prevented from doing so by other than physiological barriers.

Sebago salmon inhabit lakes that are distributed along the fringe of the presumed maximum extent of the Pleistocene glaciation in eastern North America. A population, now extinct, inhabited Lake Ontario until the beginning of this century (Huntsman, 1944). Other populations are found in lakes in southern Quebec, New Hampshire, New York, Maine, and New Brunswick (Greeley, 1948). Their growth pattern is similar to that of typical sea-going salmon, slow parr growth being readily distinguishable from a faster post-smolt-stage growth. Mature adults not infrequently attain weights of up to 15 pounds.

The Ouananiche reportedly have their area of distribution centered in the vicinity of Lake St. John, Quebec, but are much more widespread than

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is generally realized. They are found above impassable falls in many rivers flowing from the north into the Gulf of St. Lawrence. Farther north they are reported to be plentiful in both branches of the Hamilton River above Grand Falls, common in Lake Michikamau at the head of Northwest River, plentiful in the upper George River and in the Koksoak River below Lake Kaniapiskau and above Limestone Falls (Low, 1895). The fish have been taken in lakes in the centre of the Labrador Plateau near Schefferville (Knob Lake), and at Lac Aigneau in a tributary of the Larch River, again above impassable falls. In the Ouananiche growth is much slower, post-smolt-stage growth being often indistinguishable from parr growth. Mature adults average 2 to 3 pounds in weight and rarely attain 6 pounds. On the whole they are slimmer and more active than the heavier, deeper-bodied Sebago and tend to be more juvenile in appearance and proportions.

The origin and the distribution of the freshwater salmon can only be considered with reference to the Pleistocene glaciation and the events which followed this period. With the development of the ice sheets life zones moved southward ahead of the advancing glaciers. Indications are that the tundra zone immediately in front of the ice sheets was not very extensive and that the botanical zones typical of the north temperate and subarctic regions were restricted in width. Assuming that the environmental tolerances of the Atlantic salmon were at that time similar to what they are today, salmon would inhabit rivers as far north as the tundra zone. With the retreat and disappearance of the Laurentian ice sheets, life zones moved north again and rivers and lakes from which fish had been eliminated became inhabitable once more. The amelioration of the post-pleistocene climate was probably not a steady change in one direction, but a fluctuating moderation, warmer periods being interspersed with colder. Salmon recolonizing the rivers at that time would periodically be subjected to unfavourable climatic conditions coupled with instability in their environment due to changes of water-level resulting from variations in the rate of melting of receding glaciers.

Recent work by the author on the salmon populations inhabiting the George and Koksoak rivers, which are among the northernmost rivers inhabited by salmon on this continent at the present time, indicates the changes that might be expected in salmon populations exposed to a severely cold climate. Before conjecturing what these changes might involve, certain modifications in the life cycle of the salmon in these northern rivers must be mentioned.

That the length of the parr life of the salmon changes with the latitude is well known. In the south of the range parr life is short, 1 year often being sufficient for the young salmon to attain the smolt stage. The length of the parr life increases toward the north so that frequently 3 or 4 years are spent in the rivers prior to metamorphosis and migration. This increase in the duration of the parr stage is seen in its extreme development on the northern fringe of the range, where the average length of parr life is between 4 and 5 years and parr 7 years old are by no means rare. The

longer duration of parr life in the north is usually attributed to slow growth originating in poor feeding conditions, this combines with the fact that the parr have to attain a certain physiological condition, in which size appears to be a factor, before they can undergo metamorphosis.

In the George and Koksoak rivers parr growth is slow only if expressed in terms of growth per annum. If it is calculated on the basis of growth per day during the growing season it is as good, or even better, then growth farther south. The short growing season, which in these latitudes is reduced to some 10 to 14 weeks, is responsible for the small annual increments of growth shown by these fish. Another interesting observation is that the size at migration of the smolts increases in these northern rivers. This is contrary to what has been reported to happen in Great Britain and Norway where the length of parr life shows a very definite increase toward the north, whereas the size at migration generally remains fairly constant or tends to decrease. The average size in the migrating smolt population of the George River is between 21 and 22 cms. and figures for the Koksoak River would be of the same order. This is considerably larger than the size of smolts at migration from rivers farther south in Canada, where the range is usually from 12 to 16 cms.

This retardation in the juvenile stages is not evident in the post-smolt stages of the northern salmon. Once they have left the rivers their growth is as vigorous as that of salmon from much more southerly latitudes, a fact that strongly supports the idea first expressed by Menzies (1949) that some centralized feeding ground for salmon exists somewhere in the North Atlantic.

Not only is smolt metamorphosis in the George and Koksoak rivers delayed until a relatively large size is attained, but many anomalies in the process are evident. Under normal circumstances metamorphosis occurs early in the spring and the smolts migrate to the sea during the same season. In the north the same period is apparently too short for all this to be accomplished, and in the Koksoak River large numbers of fish in its upper reaches shoal up and transform into smolts, in the fall before the year of migration. Smolts can be taken in these rivers at all seasons of the year; however, the majority of the smolts that migrate to the sea in any particular year do so in June or July, which is spring in those latitudes. A number of fish, which appear to have failed to migrate, are present in these rivers. A fish taken in the Larch River, a tributary of the Koksoak, 29 cms. in length, and possibly two others, 27 cms. in length, fall into this category, as do fish taken in the George River, 29.5 cms., 32 cms., and 36 cms., in length. If such fish became sexually mature a potential freshwater population of salmon could become established.

There is little difficulty in visualizing this for the males, many of which become sexually mature as parr under normal circumstances. This holds true for the northern populations in which, besides sexually mature male parr, sexually mature male smolts are also found. Female parr, however, have never been taken in a sexually mature condition. Recent work by

Hoar (1953) and Fontaine (1954) on smolt metamorphosis and migration has stressed the importance of the neuro-endocrine changes, which are associated with the process and alter the internal environment in response to, or in anticipation of, migratory stimuli. If, under conditions of extreme cold, development of a susceptibility to migratory stimuli is retarded more than the rate of sexual development, then the females could mature prior to migration. Changes in this direction are suggested by the presence in northern populations of the exceptional fish already mentioned, which comprise about 1 per cent of the total juvenile population. Once the females begin to mature sexually as parr, the sea-phase of the salmon's life cycle would be quickly eliminated and evolutionary pressures would favour earlier maturation and a faster reproduction rate. Thus on the northern fringes of the range of the salmon, during periods in which the climate deteriorated, populations would be produced containing a relatively high percentage of fish that completed the life cycle entirely within fresh water.

In order to be perpetuated as a "race" these fish must become isolated from the normal migratory forms; this can have happened as a result of the gradual rising of the land after glaciation and the falling of the levels of many of the lakes and rivers, rendering the head waters inaccessible to migratory fish. Where the freshwater form did not become isolated from the migratory, the former was gradually assimilated into the latter's population as a result of the interbreeding that took place between the two as the climate ameliorated once more and the migratory form became again predominant in the population.

Any tendency of the freshwater salmon population, once isolated, to regain their migratory behaviour and go to sea would be suppressed at the outset, because those members that did migrate would have been prevented from returning by the physical barriers that caused the original isolation of the population.

Analysis of the growth of freshwater salmon populations inhabiting Lac Aigneau, 57°13′N. 70°08′W., and Astray Lake, 54°35′N. 66°30′W. (Fig. 1), shows the form that the growth pattern of such salmon takes under cold conditions. The growth curve of the Aigneau salmon is regular and shows no marked change in rate at any stage. The scales of approximately 50 per cent of the salmon from Astray Lake show a similar type of growth without evidence of variation in growth rate between parr and post-smolt stages, whereas the remainder indicate that a slight acceleration occurs after 3 or 4 years. This increase, however, is not of sufficient magnitude to influence greatly the calculated mean lengths on the completion of each winter band, given in Table 2, with the result that the growth curve appears regular.

This is the type of growth that would be expected in a newly evolved race of freshwater salmon inhabiting a region in which the climate was fairly severe and it is retained in the populations still living under such conditions. The races of freshwater salmon that became isolated in regions that now have relatively mild climates exhibit growth patterns similar to those of sea-going salmon. Even in Lake St. John, which is the area from

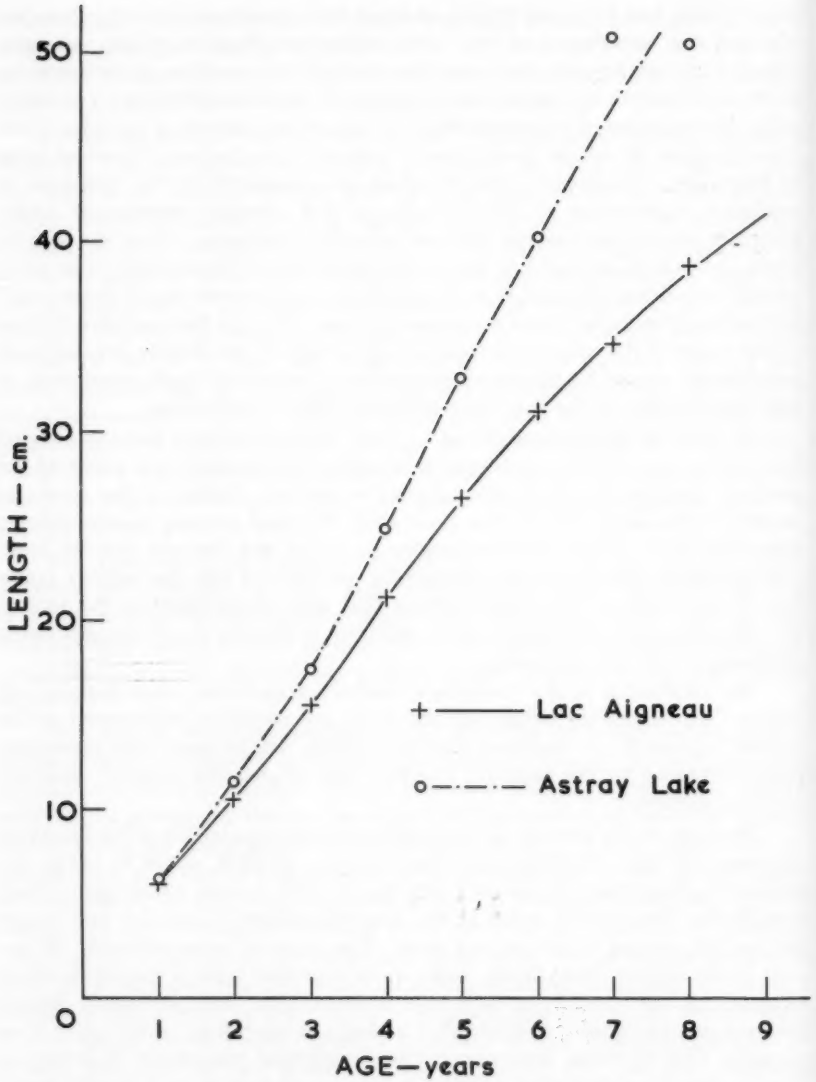

Fig. 1. Growth curves of two freshwater salmon populations.

which the Ouananiche was first described, a marked change in growth rate between pre- and post-smolt stages of the life cycle can be distinguished on the scales. Farther south, where the Sebago salmon are found, this change in growth rate after smolt metamorphosis is so clearly defined that scales of Sebago salmon can be confused with scales from sea-going salmon.

It appears that a gradual transition exists between the forms found in the extreme northern part of the area and those found in the southern part. The apparently different growth patterns are the result of the differences in length of the growing season and in the amounts and type of food available. The numerous isolated populations of freshwater salmon, distributed over the entire range from north to south, form a cline and therefore ought not to be considered as two separate subspecies, but rather to represent an assemblage of variable forms, which can be distinguished from the parent form by loss of the marine phase of the life cycle.

The condition found in the salmon is thus very similar to that which exists in its near relative, the European trout. The various extreme types of this are represented by the brown trout of the rich, slowly flowing rivers of the plains and the mountain trout of the cold, rapid mountain streams. The sea-going phase, the sea trout, is quite different again, being distinguishable from the others because of its habit of migrating to the sea for part of its life cycle. These extremes are all considered to be varieties of one very plastic species, *Salmo trutta* (L.), which are morphologically indistinguishable from one another.

The hypothesis outlined in this paper regarding the evolution of the freshwater salmon is intended merely to serve until further data can be collected. Such data should allow separation of the physiological factors concerned with migration from those concerned with reproduction and also an appraisal of the effects of severely cold climatic conditions on these two phenomena.

Table 1. The growth of Ouananiche from Lac Aigneau

Number of specimens	*Calculated mean length in centimetres on the completion of each winter band*								
	1	2	3	4	5	6	7	8 years	
3	6.2	9.8	14.8	20.3	25.7	29.5	34.0	38.7	(39.8;8+)
6	5.5	9.6	14.7	20.1	25.3	30.4	34.9	(37.5;7+)	
8	6.1	10.6	15.6	20.7	26.5	32.1	(34.4;6+)		
4	6.3	11.4	16.4	23.1	28.7	(31.6;5+)			
2	7.0	12.0	17.5	24.0	(27.0;4+)				
Total 23	6.1	10.5	15.5	21.2	26.5	31.0	34.6	38.7	39.8

Table 2. The growth of Ouananiche from Astray Lake

Number of specimens	*Calculated mean length in centimetres on the completion of each winter band*							
	1	2	3	4	5	6	7 years	
2	6.4	11.5	17.0	24.0	31.5	38.4	45.4	(50.5;7+)
2	7.4	11.9	19.3	27.1	40.3	49.3	(56.3;6+)	
4	6.6	11.5	18.8	26.2	33.1	(38.6;5+)		
7	6.1	11.2	16.6	23.9	(30.8;4+)			
3	6.2	11.2	16.0	(24.0;3+)				
Total 18	6.3	11.4	17.4	24.8	32.8	41.2	50.8	50.5

In the calculation of the means in Table 2 the figures in brackets () have been included as representing a full year's growth since they represent measurements of specimens collected in September, at the end of the growing season.

Meanwhile, it seems that mere physical isolation does not suffice as explanation of the present distribution and characteristics of the freshwater salmon of eastern North America. Physical isolation has occurred in some cases that no one would dispute; however, since many of the freshwater populations now have access to the sea but do not take advantage of it, a physiological as well as a physical cause is necessary to explain all the facts.

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OBSERVATIONS ON THE BEHAVIOUR OF CERTAIN ARCTIC BIRDS

E. O. Hohn*

In the summer of 1955 I made an ornithological expedition to the mouth of the Anderson River, N. W. T., Canada, which was supported by a grant from the Banting Fund provided through the Arctic Institute of North America. The period from June 3 to 21 was spent at Aklavik and that from June 21 to July 1 at Tuktoyaktuk. Except for a week spent at Harrowby Bay in mid-July, I remained at or near the mouth of the Anderson River from July 1 to August 24.

After the Anderson River was reached I was on my own, though unexpected meetings with a white trapper from the upper Anderson River, a geographical survey party, and a temporary R.C.A.F. detachment, followed. Certain disadvantages attendant on working alone in a wilderness area became very apparent. Much time was spent hunting and fishing in order to feed myself and the Eskimo dog that I had brought with me from Tuktoyaktuk as companion and pack dog. Travelling and collecting as many birds and small mammals as possible made up part of my programme. These demands on my time had the result that observations on bird behaviour were often incidental rather than systematic. Nevertheless, for some species the observations reported below add new facts or corroborate the somewhat meagre data available in the literature.

All observations were made near the mouth of the Anderson River, 69°59'N. 129°W., in 1955, except where another year or locality is specifically mentioned. Subspecific names are used only when the local subspecies has been determined by Mr. Earl Godfrey of the National Museum of Canada from specimens collected in 1955.

Two observations of a general character are presented first and these are followed by observations made on certain individual species.

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The effect of avian distraction displays on an Eskimo dog

The dog, which was my companion from July 1 to August 24, was a 1½-year-old male, with some previous experience as sled dog but none as a pack dog. He showed apparently natural hunting instincts and when unleashed would hunt birds and lemmings with vigour and occasional success and had to be restrained from mauling birds that were shot in his presence. The reactions of this dog to avian distraction displays were presumably very similar to those of a wolf and in general terms similar to those of the arctic fox, both important predators on the tundra. Distraction displays made by adult birds with young were completely effective in drawing the dog away from the young and causing him to pursue one of the adults, which would later rejoin its family. This happened in all encounters with American golden plover, rock ptarmigan, and willow ptarmigan. Breeding pairs with young of the last-named species were encountered very frequently. No failures to decoy the dog away from the young were seen, for no other species of birds with young were encountered when the dog was loose. Once he snapped up a downy semipalmated sandpiper, but on this occasion the parents were either not about (a point that I neglected to note at the time) or if present, they certainly did not perform a distraction display.

Hunting habits of certain falcons in relation to a human intruder

About midnight on July 24 at Harrowby Bay I took a walk through an area of low willow scrub, flushing a number of Lapland longspurs, which had been roosting in this cover. Suddenly there was a "wooshing" sound just behind me and a peregrine falcon flashed by within a few feet and then climbed up steeply, having apparently just missed a stoop at one of the longspurs.

On July 2 a grey gyrfalcon, which had no nest or young close by, glided about me in circles at a surprisingly close range.

On August 21 and again on the 23 a pigeon hawk appeared on the wing rather suddenly and made one or two low-level flights around me before taking off.

It seems that these hawks were taking advantage of the possibility of small birds being flushed by my progress and that they may react similarly to any large mammal on the move. In arctic areas a large mammal encountered in this manner would rarely be a man and he, if he were a native, would not be dangerous to hawks. The habit noted above is analogous to one reported from the Sudan, where certain birds are said to follow elephants for the sake of insects disturbed by their passage.

Observations on individual species

Arctic loon, *Gavia arctica pacifica*

The following calls were repeatedly recorded from loons of this species: a cat-like wailing "pwoo hooee, pwoo hooee", a dog-like yelp, and a growling "kurr".

The following alarm and distraction behaviour was observed on July 16 when a pair with two downy young (one of which was collected) were encountered. At my approach the swimming adults repeatedly uttered the "kurr" call. When I was quite close to the downies the adults gave a dog-like yelp "yup" while swimming in a guarded manner toward me. Each yelp was followed by a sudden noisy "crash dive" of short duration and these yelps and dives were repeated several times.

In contrast, a bird of this species that I disturbed on a nest with eggs in July 1953 on southwestern Banks Island merely slipped off the nest quietly and remained silent and inconspicuous.

In July and early August groups of three to four birds were repeatedly seen in the evenings when it appears breeding birds visit other adults on neighbouring lakes. These groups engaged in a social "play" probably tinged with sexual and aggressive significance. Individuals would give the "kurr" call while swimming with the throat and the pale-grey plumaged areas of the head distinctly puffed out. The feline "pwoo hooee" call was also uttered as well as variants of this call, which may be recorded as "maaoo" and "trr wheeoo". Finally, the yelps followed by crash dives were given, first by one, then by another bird, in quick succession. A similar midsummer evening display of four adults was seen on July 29, 1949 in the Mackenzie Delta. In that instance, in addition to much calling and diving, wing flapping and short flights were also observed. Midsummer gatherings of this type have been recorded in the European range of the species (Witherby *et al.*, 1943). The growling and yelping calls apparently indicate excitement associated with fear and alarm or with aggression and display to the opposite sex. However, it is possible that both are basically part of sexual display and occur by displacement, as defined by Thorpe (1951), during the distraction behaviour of birds with young.

Yellow-billed loon, *Gavia adamsii*

There is little information on the courtship call of this loon. On Banks Island in the summer of 1953 I heard loon calls on several occasions from birds, which were out of sight, in an area where this species was fairly common and where some specimens were collected. I have never heard this call in areas where only the two smaller loons occurred. It was a loud "yodelling", very reminiscent of the call of the common loon, *Gavia immer*. It was clearly the homologue of the feline calls of the two smaller loons but more complex and more prolonged.

Red-throated loon, *Gavia stellata*

On July 15, just off shore near the mouth of Mason River, a group of four of these loons was seen in display. Individuals uttered a mewing call from time to time and at the same time puffed out their throats. Two of the four birds rushed about swiftly in the water in a nearly upright attitude with only the rear of the body submerged and raised head and extended neck. This appears to be the "plesiosaur race" described by Huxley (*quoted in* Witherby *et al.*, 1943) and is reminiscent of the more extreme but similar display well known in the western grebe. The "roll growl" call said by Huxley to accompany this display was not uttered by the birds I observed.

In the morning of July 23 at Harrowby Bay there was much flying about of red-throated loons, which gave the usual "ka ka ka ka" flight call. These birds frequently went into long glides with the wings held stiffly at an angle of about 15° above the horizontal and the head markedly below the level of the body in a posture similar to that recently described by Sutton and Parmelee (1956) in the arctic loon, but without the lowering of the feet.

Old-squaw, *Clangula hyemalis*

T. H. Manning, in correspondence, has raised the problem of where subadult males of this species spend their first summer. The observations to be reported here (although I was not able to collect a subadult male) throw some light on this question. At Tuktoyaktuk during the period from June 22 to July 1 males with noticeably short central tail feathers, presumed to be yearlings, came to a coastal lagoon, whereas at small lakes a little farther inland only adult males and females were seen. On the lagoon, around which there were probably several old-squaw nests, adult males, some in breeding plumage, but at least two still in winter plumage, were at times seen swimming about and calling. Females would emerge from the shore and were courted by the adult males, which swam with horizontally extended necks after the females. From time to time short-tailed males flew into the lagoon from the sea and began courting the females but were always chased off by one or the other of the adults males. This would suggest that yearling males do not pair and are unlikely to succeed in mating. They appear to spend the nesting season largely at sea but at least to some extent close to breeding grounds.

Willow ptarmigan, *Lagopus lagopus albus*

Distraction display: Two females, disturbed while incubating on July 1, did not display at all. However, Hanson *et al.*, (1956) recorded that an

incubating female rock ptarmigan attacked the observer with spread wings and uttering a hissing noise.[1]

A female willow ptarmigan with newly hatched downy young encountered on July 1 came at me with laterally extended wings. The male was close by but took no part in the attack. Other instances of attacks on people by females with young of this species are reported by Höhn (1957). Later, when pairs with young able to fly were encountered, both adult birds would approach me and then feign injury. Generally the male would approach closest and the female would return to the young, ultimately to be rejoined by her mate. It appeared that while the young are unable to fly the female is more active in distraction display but that later when the young are able to fly she tends to remain with the chicks while the male attempts to lure away the intruder by injury feigning. Thus on August 10, while out with the dog, I encountered three ptarmigan families in succession along the shore of the Anderson River. On each occasion the female and young flew over the bank while the male allowed close approach and then drew off the dog by short, low-level flights. Evidence of the break-up of family groups was observed on August 11; on this day a group consisting only of adult males was encountered, as well as several females each with young but without an attendant male. On being disturbed these females took off to a distance, without any attempt at injury feigning, nor did they appear to rejoin their young.

Evidence of non-breeding: Willow ptarmigan and, more locally, rock ptarmigan were unusually abundant in the summer of 1955 about the mouth of the Anderson River. On the north shore of Harrowby Bay a flock of at least forty and another of ten adult willow ptarmigan, as well as one flock of seven adult rock ptarmigan were seen during the period July 18-26. Since breeding birds would have either young or eggs at this time, these birds must have been non-breeders. It is possible that the high density of population may have inhibited breeding, as there were no indications of lack of nest sites or food.

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[1]The following observations may be of interest.

At about 2300 on July 14, 1954 near Eureka, Ellesmere Island, I was walking along the foot of a creek bank, with my eyes on the ground watching for plants and insects, when suddenly, with a loud whirring of wings, hissing, and snapping of mandibles, a bird almost flew into my face. It took a second or two to recover and then I saw the cause of all the commotion: a brown rock ptarmigan hen was standing in a clump of *Cassiope* in threatening attitude, ready to fly at me again. She did so in a half-hearted way when I stepped forward and nearly into her nest with six eggs in a deep depression between hummocks. Continuing on my way, the hen kept abreast of me at a distance of some 100 feet for the next 200 yards, feeding a little here and there, but always watching me closely.

On July 6, 1952 at Mould Bay, Prince Patrick Island, a female of the same species was discovered on her nest almost in the weather station area, only a few feet from a well-travelled tractor trail, just when the young were hatching. This hen let herself be stroked and even picked off the nest without any fuss whatever. — *Edit.*

Semipalmated plover, *Charadrius semipalmatus*

Distraction displays by adults in charge of downy young were observed on July 8 and 28. On the first occasion a pair of adults ran ahead of me along the sandy shore, holding their tails depressed and fanned out. From time to time one of them stopped and still keeping the depressed, fanned-out tail toward me drooped both wings and waved one. On the second occasion a single adult bird was involved. It also ran ahead of me with its tail fanned out and depressed to such a degree that the tips of the tail feathers actually scraped the sand. While running the wings were held in the normal, closed position but their tips, that is the portion visible from the rear above the depressed tail, were waved in a rapid, tremulous motion. Much the same distraction display was observed in birds of this species by Scott on the Perry River in 1949 (Scott, 1951).

Least sandpiper, *Erolia minutilla*

Display flight: On June 7 and 8, 1955 the song flight of this species was seen within the settlement of Aklavik, where a nest with four eggs was found on June 20. The bird was circling about 50 feet above the ground, at times gliding with the wings elevated above the horizontal and interrupting the glides by short flights with peculiar tremulous motions of the outer parts of the wings. The song, which accompanied this flight, was a repeated "torri trri", which changed at times to "wee wee wee", the second version being reminiscent of the song of the spotted sandpiper. This description of the song flight is essentially similar to that given in Bent (1927).

Stilt sandpiper, *Micropalama himantopus*

Display flight: On July 4 I encountered several adults with downy young in a salt marsh beside the Anderson River. The song flight of the adults was delivered while hovering, facing the wind, 10 to 20 yards above the ground. The song was a repeated "whooee whooee", varying in loudness and frequency of repetition, and changed to "pooee" on landing. A call apparently indicating wild alarm was "churr" or "purr". Bent (1927) gives no information on the courtship of this sandpiper.

Northern phalarope, *Lobipes lobatus*

The display of this phalarope has been fully described by Tinbergen (quoted by Witherby *et al.,* 1943). However, the following observations made in June 1955 at a coastal lagoon at Tuktoyaktuk where these birds were almost certainly nesting are worth recording. On this lagoon females

held and defended segments of the shore line each about 20 yards long by patrolling on the water and chasing other females. Males were almost invariably seen only on shore where they were skulking among the marsh grasses. I collected a female as well as a male to confirm beyond doubt the sex of one of the individuals active in territorial defence.

Parasitic jaeger, *Stercorarius parasiticus*

The distraction display of this jaeger has been described in some detail by Williamson (1949). However, a display I saw on July 23 at Harrowby Bay included a feature not recorded by Williamson. The members of a solitary pair, which had a downy youngster, alternately made low-level, stooping flights over me, calling "gwük" or "kwooeek". Williamson does not mention the calls that accompanied this aggressive display in his observations and Witherby *et al.* (1943) state, in connection with stooping flight attacks, that they are accompanied by a "tuneless tick-a-tick call". While one of the adults observed by me was making a series of flight attacks, the other was generally on the ground giving the "lure display", that is injury feigning, much as described by Williamson. This was accompanied by a feeble "peep peep" call that, as Williamson suggests, may well be derived from the food-begging call of the young bird. A feature not included in Williamson's description of the "lure display" shown by both the adults that I observed was a fluttering of the wings while only one foot remained on the tidal mud. This created very realistically the impression that the bird was caught by the foot.

Predatory behaviour: The jaeger's habit of chasing terns to make them drop their prey, which is then seized by the jaeger is well known. However, during nearly three months spent at the mouth of the Anderson River only one such pursuit of a tern was seen. On August 13 two parasitic jaegers were seen chasing in co-operation with one another a flying semipalmated sandpiper. At one time one of the jaegers actually had a grip on the sandpiper, apparently on its wing. The sandpiper managed to free itself but the chase continued out of sight and it is likely that the sandpiper was ultimately killed. On July 13 a parasitic jaeger was seen mobbing a grey gyrfalcon.

Long-tailed jaeger, *Stercorarius longicaudus*

Distraction display: The literature on the distraction display of this jaeger is briefly reviewed by Pitelka *et al.* (1955). Some observers recorded a distraction display, whereas others did not observe it in nesting birds of this species. Hansen *et al.* (1956) note that there was a great range of individual variation in the aggressiveness of different pairs, some abandoning the nest area altogether when an observer was at the nest. At one nest with eggs, one of the adults repeatedly struck the observer on the head during stooping flight attacks.

On July 23 I came across a solitary pair of these jaegers which had a downy youngster on a hillock in a grassy valley near Harrowby Bay. Before the disturbance one of the adults was on guard on a hill along the side of the valley above the hillock that sheltered the youngster while the other parent was in close attendance on the chick. At my approach the two parents regularly alternated aggressive displays, that is, stooping flights with the "lure display" performed on the ground. Gliding stoops were made to within a few feet of me but no actual contact was made. The stoops were accompanied by "kwooeek kwooeek" calls. Scott *(in* Hanson *et al.*, 1956) describes a "curiously musical scolding note", uttered in flight attacks.

The "lure display" was of the injury-feigning type, consisting of wing flapping accompanied by a peeping call. Both forms of display were continued after I had caught the youngster and placed it in my rucksack.

Glaucus gull, *Larus hyperboreus barrowianus*

The call of the young glaucus gull does not seem to have been recorded. On August 23 flying young called "kiarr örr örr" only. This was to my ears much like the call of immature herring gulls but perhaps deeper in pitch. From downy young I heard a peeping call quite like that of the young of other large gulls.

Sabine's gull, *Xema sabini*

Descriptions of the call of this gull (Witherby *et al.*, 1943) are somewhat vague. On July 23 at Harrowby Bay the following rendering of the call was recorded: a tern-like "tä trr i ik". This was uttered by a pair hovering above me and probably indicated mild alarm.

Arctic tern, *Sterna paradisaea*

On August 13 I heard from a flying young bird a call that does not appear to have been described. It was a deceptively faithful imitation of the "whistling" sound of a mallard's wing beat, but was delivered vocally by the tern.

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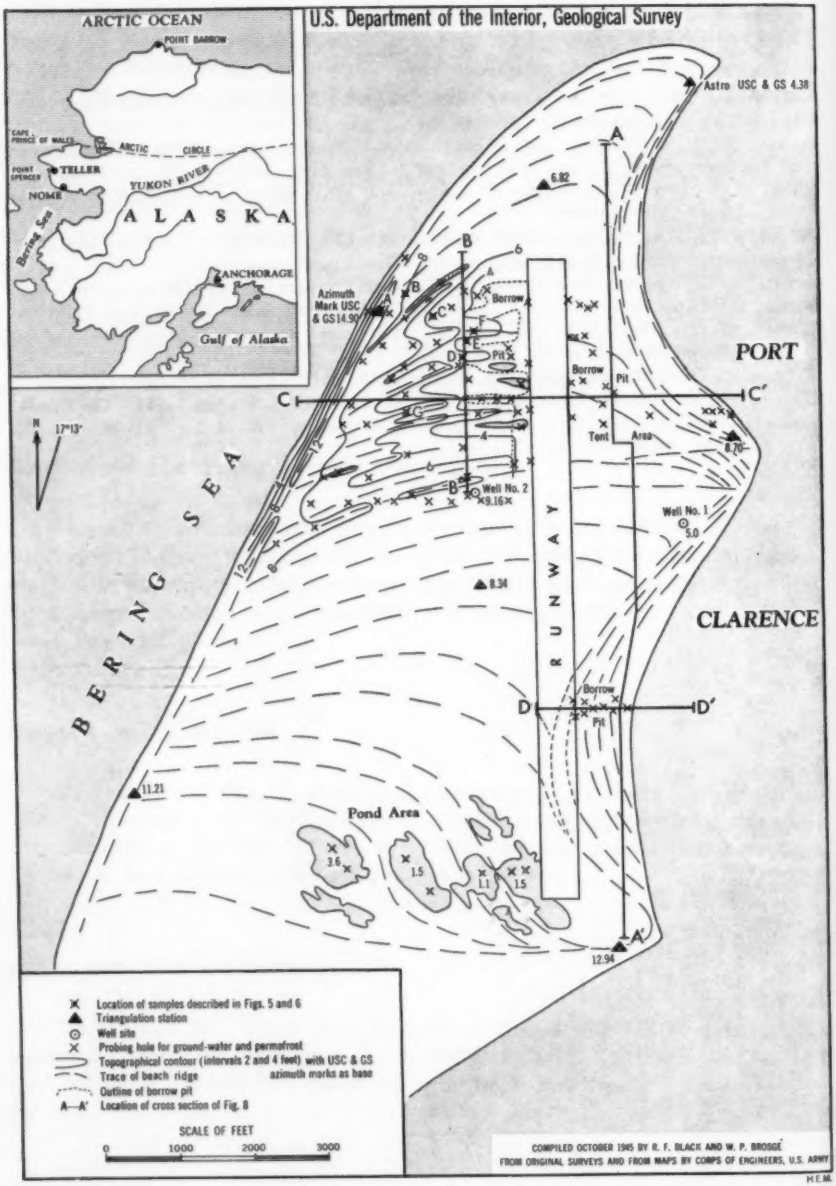

Fig. 1. Sketch map of Point Spencer, showing topography and locations of beach ridges, of probing holes, of cross-sections in Fig. 8, and of samples in Figs. 5 and 6.

PERMAFROST, WATER-SUPPLY, AND ENGINEERING GEOLOGY OF POINT SPENCER SPIT, SEWARD PENINSULA, ALASKA*

Robert F. Black†

POINT Spencer (Fig. 1) is the enlarged northern tip of a spit that separates Port Clarence from the Bering Sea, near the western end of Seward Peninsula, Alaska. During construction of a temporary airfield there in 1945 army engineers experienced difficulty in excavating into permafrost and in obtaining an adequate water-supply. The U.S. Geological Survey was requested to make a geologic reconnaissance of the spit in the autumn of 1945, and this was done by the writer, aided by William P. Brosgé. The purpose was to determine the character of permafrost and the availability of potable water for use by the construction group and the service group succeeding it. Inasmuch as many spits and bars along the shores of western and northern Alaska resemble Point Spencer, the results of that reconnaissance are of general interest to construction projects in similar areas.

During the period from October 10 to November 1, 1945 inclusive, a small area on Point Spencer was mapped with plane-table and telescopic alidade on a scale of 500 feet to the inch and with a contour interval of 2 feet. At that time the spit was covered with as much as 30 inches of snow, and the ground was frozen in places to a depth of 26 inches. In the area mapped (Fig. 1) the top of permafrost and the water-table were located with a ¾-inch steel drill rod 8 feet long. The rod was driven into the ground with a sledge hammer and extracted with pipe-wrenches. In a protected water-supply area, established by the engineers, holes were dug to check the results obtained by this probing for the water-table. Samples of vegetation and surface materials were collected for laboratory study.

The writer is indebted to William Brosgé for his assistance under difficult working conditions. Information and assistance provided by Lt. Col. K. E. Ristau, Major Giardinia, and Sgt. Sharp of the U.S. Army Corps of Engineers were helpful and greatly appreciated. Kenneth N. Phillips of the Surface Water Branch of the U.S. Geological Survey furnished information derived from his field observations between September 3 and 10, 1945.

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Fig. 2. Barrier ridge with sparse beach grass *(Elymus mollis)* near U.S. Coast and Geodetic Survey Azimuth 14.90 on the west side of Point Spencer, looking northeast. October 15, 1945.

Geography and geology

Point Spencer lies at latitude 65°17′N. and longitude 166°50′W., about 69 miles northwest of Nome. The spits extends more than 15 miles northwest and north from the mainland, although perhaps only the northern part is wave-deposited. (The base was not examined by the writer, but is reported by David M. Hopkins to be erosional). The enlarged northern part of the spit is about 3 miles long and 1 mile wide. It is joined to the mainland on the south by a low sand- and gravel-bar ranging in width from less than 100 to over 10,000 feet. The west shore of the northern part is smoothly arcuate to the hook at the tip of the spit. The east shore has two pronounced lobes that protrude into Port Clarence. The northern part is nowhere more than 14 feet above sea-level and averages between 6 and 8 feet. A prominent sand-ridge or barrier, 10 to 14 feet high, parallels the west shore (Fig. 2), and a much less pronounced, broad ridge, or set of parallel ridges, 6 to 10 feet high, parallels the east shore. Eastward-trending ridges, 6 to 12 feet high, transect the southern end of the enlarged part of the spit and terminate at the west and east shores. North of this group of eastward-trending ridges the spit is crossed by arcuate ridges that have a more northeasterly trend (Fig. 3). The old beach-ridges, which are shown in Fig. 1, are accurately located only in the small area mapped topographically, and even in that area no attempt has been made to map all ridges. At the northern end of the spit the ridges parallel the northwest shore. The relief between ridges and troughs is of the order of 2 to 4 feet. Several small ponds and swampy hollows are present, of which only a few are shown in Fig. 1; streams are absent.

The spit is covered with stunted arctic vegetation, except in a zone, 100 to 200 feet wide, along the western shore and in an area of several thousand square feet in the northern part. Grasses, sedges, mosses, and other small plants, predominate. Trees are absent, but small, prostrate willows of several species are common. In general, each type of vegetation tends to segregate into zones or patches according to type of soil and drainage. No attempt was made to map vegetational zones, most of which are too small to be mapped on the scale used.

Sparse beach-grass *(Elymus mollis)* forms a belt, 100 to 200 feet wide, along the crest of the ridge that parallels the west shore (Fig. 2). To the east the beach-grass gives way to a mixed assemblage of grasses and sedges that were not identified. Along the almost bare crests of the former beach-ridges, where coarse gravel permits rapid drainage and drying, almost no soil exists, and mountain avens *(Dryas octopetala)* and caribou moss are in many places the only plants. Along the back slopes of the ridges the sandy soil is 0.5 to 2 inches thick and the *Dryas* and mosses grade into a zone that contains elongated patches of grasses, sedges, and willows. Peaty soils, 2 to 12 inches thick, cover sand in the troughs, where water-loving sedges, crowberry *(Empetrum nigrum)*, and mosses prevail.

The spit is principally the result of transportation and deposition of material by wave action and longshore currents, and is similar in origin to the barrier-bars (or offshore bars) that extend almost continuously along the southwestern coast of the Seward Peninsula. The ridges were formed by waves and represent a series of former storm-beaches. Thus they record stages in the construction and destruction of the spit and suggest that the

Fig. 3. Former beach ridge and trough that trend diagonally northeast across Point Spencer, from a point near U.S. Coast and Geodetic Survey Azimuth 14.90, looking northeast. October 15, 1945.

spit was intermittently extended from south to north and at the same time was moved eastward.

Material is now being transported generally northward by longshore currents and waves on the Bering Sea shore and is being deposited at the tip of the spit on the northern and eastern sides. Only a negligible quantity of material is moved by ice-shoving compared with that transported by waves and currents. Wind has sorted some of the sand and has deposited several layers a few inches thick on the barrier-ridge along the west shore. Deposition of gravel by wave action from Port Clarence has filled in and smoothed out the indentations of the east shore.

Constructive and destructive wave actions vie with one another, and during October 1945 measurements made on the northern tip of the spit revealed a change in position of the shore-line of as much as 100 feet during one stormy night. The changes in the shore-line are brought about mostly by wave action resulting from sudden changes in wind direction and velocity and only to a smaller extent by the tides, which are less than 2 feet.

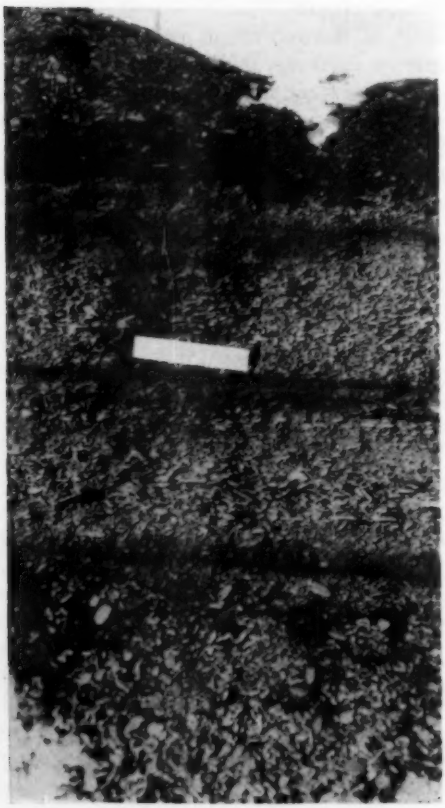

Fig. 4. Gravel and sand in stratified layers and lenses exposed in an excavation about 200 feet southeast of well No. 1 (Fig. 1). October 15, 1945.

Undecayed driftwood covers the barrier-ridges on the western and northern sides of the spit (Fig. 2) and extends inland for several hundred feet. Storm waves have washed over the barrier-ridges through passes and breaks 10 feet above sea-level and have built recent deltas and fans a few inches to 2 feet high and 10 to 50 feet wide on the land side of the ridges. These features suggest partial, if not complete, inundation by the sea in comparatively recent times. One complete inundation, during a storm accompanying or following the eruption of Mount Katmai in 1912, has been recorded.

The old beach-ridges are composed of gravel and sand in stratified layers and lenses (Fig. 4). The upper surface of the lenses parallels the surface of the former beaches, and the lenses are a fraction of an inch to 30 inches thick, a few inches to 20 feet wide, and as much as several hundred feet long. In general, the coarser material makes up the ridges, whereas most troughs contain a layer of sand or peaty soil at the surface. About 85 per cent of the coarse-grained surface material is composed of discoidal limestone pebbles. The pebbles may have been derived from the limestone of uncertain age that outcrops on the mainland to the east and south. However, the writer has not seen these outcrops. Most pebbles were deposited in such a way as to form an overlapping shingle-like structure. Smaller pebbles of fine- to coarse-grained granitic rocks, slate, and schistose rocks, are present in small quantities. The finer material is principally quartz but includes fragments of garnet, hornblende, pyroxene, epidote, mica, feldspar, chert, dolomite, and other minerals. Heavy minerals such as magnetite and ilmenite were not seen. Shell fragments in small quantities are common. Silt-sized particles of rocks and minerals are negligible in quantity (Figs. 5 and 6).

According to two well-logs made by the army engineers the typical wave-deposited sand and gravel section is 34 to 36 feet thick and rests on 8 to 36 feet of black muck. The muck is underlain by a series of alternating beds of black clay, black silt, sand, and gravel, to a depth of at least 298 feet.

Climate

The climate at Point Spencer is subarctic-marine; that is, cold, cloudy, windy, and humid, but with only low to moderate precipitation. Incomplete records from the U. S. Weather Bureau station at Teller, on the mainland 14 miles east of Point Spencer, show that from 1931 to 1940 the mean annual temperature there was 25.2°F. and the mean annual precipitation was 11.1 inches. Table 1 shows the mean monthly temperature and precipitation at Point Spencer for 1 year. During that period the minimum temperature was —33°F. and the maximum was 74°F.; the annual mean temperature was 21.8°F. The greatest precipitation during one day was 1.13 inches on January 23, 1945. The low temperature, high winds, high humidity, and cloudiness, are favourable for the growth of permafrost at Point Spencer.

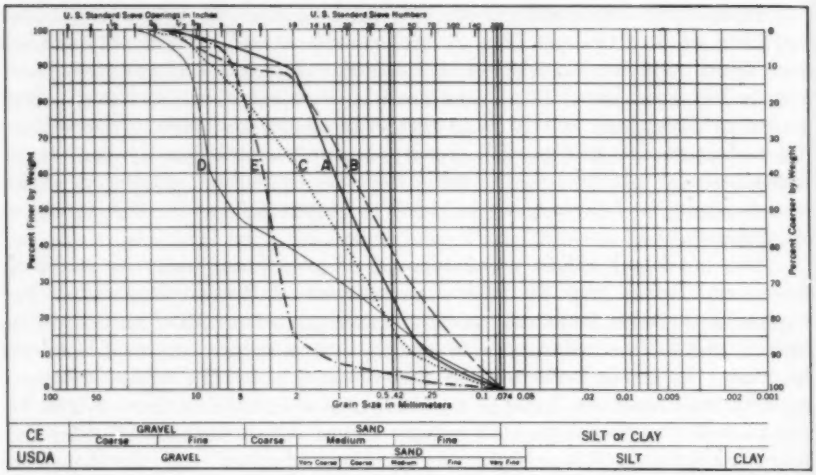

Fig. 5. Graph showing grain-size distribution of samples of sand and gravel from Point Spencer. See Fig. 1 for locations.

From October 10, 1945 to November 1, 1945 inclusive there were falls of sleet or snow flurries on 19 of the 22 days and the surface of the ground, except for the higher ridges, was covered with as much as 30 inches of snow. During October the average wind velocity was 16 miles per hour and the greatest velocity was over 47 miles per hour. The prevailing wind direction was NNE. During that month 66 per cent of the days were overcast, 14 per cent had broken clouds, 12 per cent had scattered clouds, and 8 per cent were clear. On October 18 and 19 very strong winds from

Table 1. Temperature and precipitation data for Point Spencer, Alaska. Compiled from records of the 16th Weather Region, Regional Control Office, U.S. Army.

	Average mean temperature in degrees F.	*Precipitation in inches*
November 1944	11.5	0.25
December	6.5	0.50
January 1945	4.8	1.54
February	—0.8	1.29
March	—7.7	1.16
April	19.8*	0.12*
May	25.0	0.66
June	37.4	0.11
July	47.9	1.65
August	45.2	2.49
September	43.0	1.87
October	28.8	1.32
Annual mean temperature	21.8	Annual precipitation 12.96

* First seven days in April were not recorded.

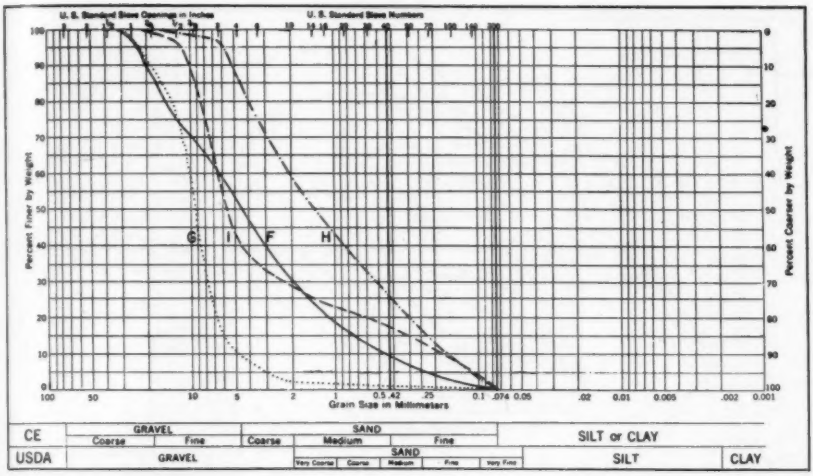

Fig. 6. Graph showing grain-size distribution of samples of sand and gravel from Point Spencer. Samples G, H, and I were taken at the spot marked G in Fig. 1 at depths of 30 to 35 inches, 25 to 30 inches, and 4 to 17 inches, respectively.

the north blew much of the snow cover off the spit. After several more inches of snow had fallen, very strong easterly winds on October 25, 26, 28, and 29, repeated the process. These winds caused the flooding by salt water of borrow pits along Port Clarence.

Permafrost

Perennially frozen layers of gravel and sand cemented with ice underlie most, if not all, of the enlarged northern part of Point Spencer pit and extend outward for several feet beyond the shore. The pores of the sediments are entirely filled with ice and in many places there is more ice than normal pore space. In the area shown in Fig. 7 the depth to permafrost ranged from 3 feet to more than 8 feet in October 1945. The top of permafrost was roughly parallel to the surface of the ground, but irregularities on the permafrost-table commonly were less pronounced than irregularities in surface relief. Thicker vegetation and abundant moisture in the swales prevent rapid thawing, and permafrost is there closest to the surface. The top of permafrost in a small area on the Point is illustrated by contours in Fig. 7 and by cross sections in Fig. 8. At wells No. 1 and No. 2 (Fig. 1) the base of the permafrost was 12.5 and 17.0 feet below the surface or 7.5 and 8.0 feet below sea-level, respectively. It seems likely that the base of the permafrost is irregular and that it is in general roughly parallel to the top.

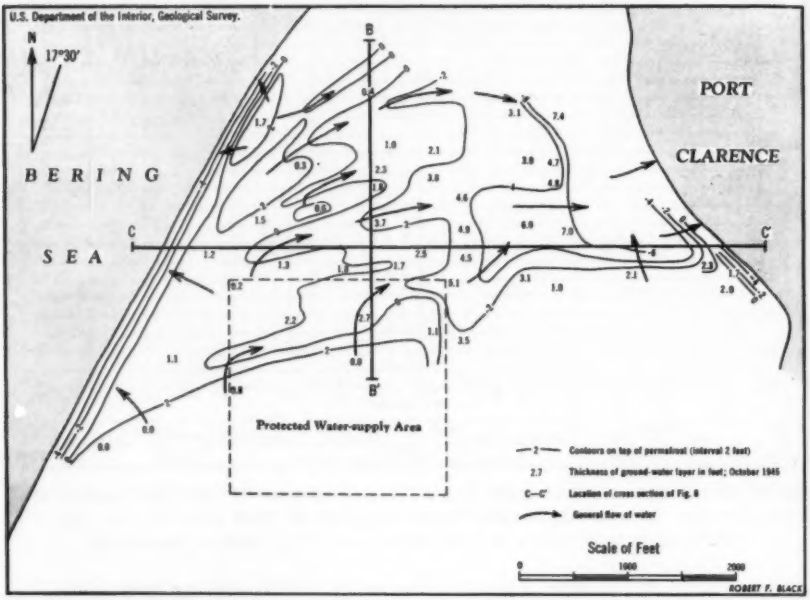

Fig. 7. Map showing contours on top of permafrost and thickness of groundwater layer on part of Point Spencer spit.

Records kept by the 331st Engineers show that the frost-table was from 6 to 30 inches below the surface in July 1945. In order to obtain material from the deeper borrow pits it was necessary to allow the frozen ground to thaw to a depth of several inches from time to time, so that another layer of sand and gravel could be removed by bulldozers. By November 1945 the depth to which freezing from the surface had advanced was as much as 26 inches and it is believed that during normal winters the active layer freezes completely down to permafrost. Freezing penetrates deeper and more rapidly where snow cover and vegetation are thin or lacking.

According to records of the army engineers one icing mound or ice laccolith near the north end of the runway was removed when the runway was constructed in July 1945. The icing mound consisted of a dome-shaped lens of ice, 30 feet in diameter and 1 foot thick, under 1 foot of peaty soil. Such ice lenses are common features in other areas of the Arctic; they are formed in the fall when the active layer freezes, trapping soil water under pressure between the downward-freezing surface and the impermeable permafrost below. Polygonal patterns were recognized to the south of the pond area (Fig. 1) in the older part of the spit; they were not investigated in the field, but presumably are analogous to the ice-wedge polygons of other parts of Alaska.

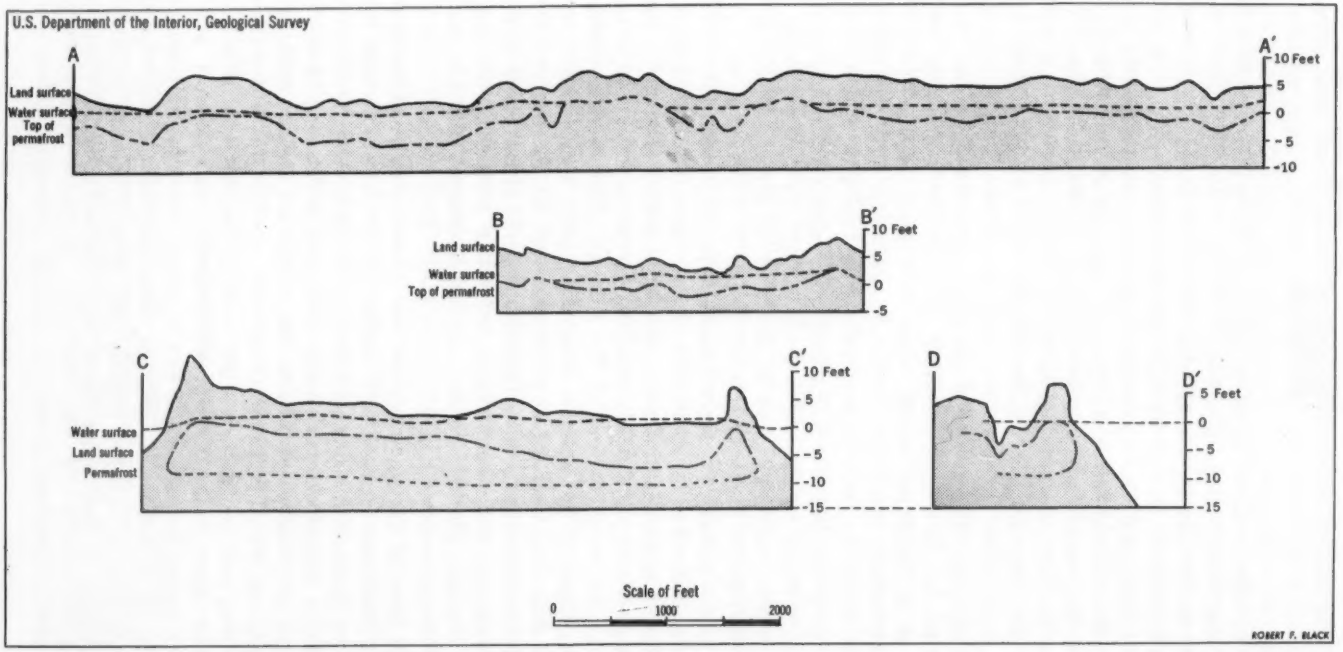

Fig. 8. Representative cross-sections across part of Point Spencer spit, showing land surface, top of permafrost, and water surface.

Hydrology

Fresh water on Point Spencer is derived from rain that falls directly on the spit and snow that falls or is blown on to it. Water from rain and melting snow that is not evaporated or transpired is trapped in irregularities on the permafrost in form of a perched water-body. It is normally available for use only in the summer, because during the winter it is contained as ice within the active layer. The average annual precipitation is only 11 inches according to records of the U.S. Weather Bureau, and much of it is in the form of snow that drifts off the spit before it can melt and augment the water supply. In the fall and early winter the snow blows into the open water before ocean and bay freeze and is lost. Hence, recharge of fresh water is limited. In Fig. 7 the presence of ground-water is indicated by figures, which show the thickness of water-saturated material on top of the permafrost. Cross sections of the ground-water body and the permafrost are shown in Fig. 8. Irregularities in the water-table are due in part to the fact that measurements at different places were made at different times. The probable ground-water circulation during October 1945 is indicated by arrows in Fig. 8. The porosity of the sand and gravel averages about 15 per cent and the permeability is very high; hence, the water-table rises and falls very rapidly after rains or thaws.

The permafrost-table is the principal factor controlling the distribution of ground-water, which is essentially absent above the higher permafrost ridges. Water is most abundant in the large borrow pits excavated into permafrost between the runway and Port Clarence, and in the freshwater ponds near the southern end of the runway. Under the barrier-ridges along the edges of the spit the permafrost-table rises slightly to form a natural dam, less than 2 feet above sea-level on the western side and even lower on the eastern side. This dam impedes the drainage of ground-water out to sea and also prevents sea-water from polluting the fresh water on the spit. Thus the fresh water lies in natural basins in the upper surface of the permafrost.

Rapid rises of the water-surface are caused chiefly by precipitation, melting of the frozen ground, and flooding by sea-water. Graphs supplied by the army engineers of daily positions of ground-water levels show that the maximum variation in the water-level during August and September was 1.2 feet in a freshwater pond in the borrow pit at cross section D—D' (Fig. 1) and less than 1 foot in the freshwater pond at the southwest corner of the runway and in the borrow pit north of the tent area (Fig. 1). The water-levels were highest when precipitation was greatest and they dropped, in places as much as 0.6 feet in 3 days, when precipitation ceased. From June 25 to October 10, 1945 the water-table in the protected water-supply area (Fig. 7) dropped steadily and probably closely paralleled the annual melting of the active layer and the resulting lowering of the frost-table.

During some storms sea-water flows through the gravels over the low permafrost barriers bordering the spit and contaminates at least part of the fresh water on the spit. An instance of this took place on October 26, 1945 when very strong winds from the southeast brought about the flooding with salt water of most of the borrow pits along the Port Clarence side. At least 14 inches of sea-water flooded a borrow pit (not shown in Fig. 1) at the southwestern corner of the runway; at least 13 inches of strong salt water flooded the large borrow pit north of the tent area. On October 30 water on top of the permafrost dam on the Port Clarence side was still salty. Fresh ground-water, which had been pumped since July 1945 from an excavation at a septic tank (south of the tent area, but not shown in Fig. 1), turned brackish on October 28 and was too salty for use the next day.

Fresh water near the centre of the spit is usually not contaminated, although the water-level commonly is raised by the introduction of salt water into the border areas of the spit and by the damming of the outflowing fresh water. At times salt water apparently has flowed under near-shore bodies of fresh water, both ground- and surface-water, on the spit, floating the fresh water and raising the water-level. Double layers of ice, separated by water, in the pond in the borrow pit at cross section D—D' indicated flooding by 14 inches of water. Furthermore, the double layers of ice in the pond at the southwestern corner of the runway indicated a sudden rise of water-level of at least 13 inches. These rises in water-level occurred during a time of no recharge of fresh water. It was reported by the officer in charge of the base that the water in the borrow pit crossed by section D—D' became salty about November 7 after a week of pumping the fresh surface-water.

The best source of water on the spit is probably the pond area to the west of the south end of the runway. The ponds contain 2 to 3 feet of water over a few inches of organic ooze and are underlain by sandy gravel. Permafrost is more than 6 feet below the surface. Even here, however, salt water may have contaminated the fresh water just above the permafrost-table in October 1945. Tests should be made to determine the nature of the situation before any extensive use of water from the area is made.

The two wells, one 298 feet deep, did not show any source of fresh water, and it is improbable that a good source could be found at a greater depth. When permafrost was pierced by these wells, salt water rose in them to about sea-level at depths of 5 and 9 feet, respectively.

Engineering geology

The following comments and recommendations, though made specifically for Point Spencer, are applicable in large part to other bars and spits in western and northern Alaska. The ground at Point Spencer spit is characterized by layers of well-sorted sand and gravel that in general assure a stable subgrade, whether or not permafrost is present or is

disturbed by construction work. Except for subsurface drainage, effects of temperature, and additional induration of the unconsolidated sand and gravel by ice, the construction problems are similar to those in areas of well-sorted sand and gravel free from permafrost. Although sand and gravel are abundant, other types of construction materials are essentially not available. Fine silt and clay are scarce or absent at the Point, but are reported 6 to 7 miles to the southeast. No bedrock is present at or near the surface. However, crushed limestone pebbles make an excellent binder for the loose gravel. Sand, a few inches to several feet thick, is found most commonly at the surface of the swales, whereas the ridges are composed chiefly of gravel. Sand also caps the barrier-ridge along the western side of the spit. Permafrost makes the removal of material from borrow pits or other excavations difficult because it acts as a cement in the gravels and sands. Thawing of permafrost proceeds relatively rapidly on exposure during June, July, August, and early September, but during the rest of the year artificial thawing is necessary.

The supply of fresh water on the spit is very limited and is not replenished rapidly. Therefore, precautions should be taken in any construction on the spit to determine whether or not the work will affect the water supply. Sanitation regulations to preserve the supply of fresh water must be rigid and strictly adhered to.

The construction of traps to retain as much snow on the spit as possible would help to replenish the water-supply. Excavation of hollows in the top of permafrost would tend to prevent the escape of fresh water over the permafrost barriers around the edge of the spit. However, these hollows must be kept shallow or permafrost may be pierced. This may have occurred in the deep borrow pit north of the tent area. The construction of earthen ridges around the freshwater pond area and elsewhere would tend to raise a permafrost barrier, and thus aid in preventing the pollution of these areas by the lateral flow of salt water and the escape of the fresh water to lower areas.

Heated buildings or excavations on the barrier-ridges along the edges of the spit would lower the permafrost dam and result in pollution by sea-water of the freshwater supply. Deep excavations or construction that would pierce or destroy the permafrost underlying the fresh water would allow salt water to rise or the fresh water to flow downward to sea-level, thus destroying much of the storage capacity of the area.

The withdrawal of fresh water from any part of the spit should be accompanied by surveys in the vicinity to determine if polluted or saline waters are replacing the fresh water withdrawn, and if so, to determine possible methods of preventing pollution. Surveys to determine the top of permafrost should be made annually to determine any dangerous lowering of a permafrost dam either on the edges of the spit or between areas of polluted and fresh water now existing, such as the area between the polluted borrow pits adjacent to Port Clarence and the freshwater ponds to the west of the south end of the runway.

Construction of drainage, sewage-disposal, and water-distribution systems, requires special measures to counteract the freezing temperatures encountered in permafrost, but utilidors laid on or near the surface of the ground have proved satisfactory elsewhere in areas of permafrost.

The position of the shore-line, particularly at the northern tip and at the southeastern corner of the enlarged portion of the spit, changes as much as 100 feet overnight as the result of longshore currents and wave action, and no permanent construction should be attempted on or directly adjacent to the shore, unless adequate breakwaters can be established. Frequent storms and the ease with which the sand and gravel can be transported by water or ice would make the establishment of permanent breakwaters costly and difficult.

The presence of driftwood on the highest parts of the spit and the fact that the entire spit has been inundated at least once within recent years indicates the possibility of another inundation.

Conclusions

As a terrain type for engineering considerations a spit, such as Point Spencer, can be classed among the barrier-bars or offshore bars. They can be identified by their position in relation to the mainland and by the nature of the unconsolidated, wave-deposited materials of which they are composed. From Norton Sound northward along the Bering Sea and arctic coasts of Alaska offshore bars are common. Permafrost, water-supply, and availability of construction materials in many bars probably are similar to those at Point Spencer. Such wave- and current-formed bars are commonly composed of lenses and layers of well-sorted sand, or sand and gravel. The size and composition of the material is dependent in part upon the material on the ocean floor adjacent to the spit and upon the character and proximity of bedrock in the vicinity. For example, at Point Spencer much of the material consists of flat, disk-like plates of limestone, whereas at Point Barrow most of the material in the beach is composed of well-rounded spheroids of chert. The thickness of the coarse material in a bar depends principally upon the accessibility to waves, the availability of material, and the stage in the development of the bar. The sand and gravel may be only a few inches or as much as several tens of feet in thickness, and may or may not rest on fine-grained silt or muck containing considerable organic matter. Perennially frozen, fine-grained silt or muck characteristically contains much ice as cement, grains, and clear masses of various shapes, as at Point Barrow. Therefore, before any large-scale construction is attempted, bars should be thoroughly investigated for subsurface conditions. The effects of frost-heaving and slumping are likely to be relatively slight in bars of coarse sand and gravel, but disastrous in bars of fine-grained materials.

The supply of fresh water on offshore bars and spits is always limited, and to obtain an adequate supply is likely to be the most difficult problem

in construction. Permafrost commonly is the factor that permits the water to be retained. Therefore, it must receive first consideration in the utilization of the bar or spit for engineering purposes if the current water-supply is to be maintained on a yearly yield basis.

Although the general geological history, permafrost, water-supply, and availability of construction materials, at Point Spencer have been established in reconnaissance fashion, direct comparisons should not be made with other bars or spits unless it can be determined that they had a parallel geological history and are subject to a similar climate. Most must be treated as individual cases; however, many problems and their solutions are undoubtedly common to all. In particular, the principle seems well-established that water-supply is usually economically feasible only if natural or artificial basins in permafrost can be preserved.

NAMING OF BIRDS AS PART OF THE INTELLECTUAL CULTURE OF INDIANS AT OLD CROW, YUKON TERRITORY

Laurence Irving*

It is easy for people unfamiliar with living conditions in the Arctic to believe that special physical abilities are necessary for the continued existence of arctic peoples. It is harder to recognize that intellectual competence also is required for the special cultural adaptation of a small community to living independently under arctic conditions. Modern science and technology rely so much on the printed word that it is difficult for us to communicate accurately with people whose only records of knowledge consist of the remembered meaning of spoken words. Our attempt to communicate with Indians is hindered by the necessity of using our language, established for quite other circumstances than theirs, with concepts and vocabulary limited by our rudimentary familiarity with the objects and conditions surrounding the people who live in the arctic villages.

When making preparations for the U. S. Public Health Service Alaska-Yukon Expedition to Old Crow, Y. T., I had hoped to receive assistance from the resident Indians in studying the life of their country. When we began work, at first a few individuals and soon most members of the community showed their interest in satisfying our curiosity about their life and environment. This sympathetic acceptance of our purpose favoured mutual understanding so that I was able to compare the recognition and naming of birds by the resident Indians with the list of birds of that area prepared by our scientific methods. One of the older Indian residents at Old Crow recognized and named in his own Kutchin language every species shown to him by the collectors and unmistakably described a few that we did not find. This informant, Joe Kay, obtained for us a number of especially valuable specimens. He apparently knew when and where to look for each migratory species and often was the first to report a new arrival. For example, he collected a violet-green swallow for us 3 weeks before we saw one ourselves. He distinguished it from the tree swallows, which were then common near the village, and said that he knew it as the "mountain swallow" of his earlier experiences.

In two arctic communities of Alaskan Eskimo I have found recognition of and names for most of the birds that I could distinguish there by

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scientific study (Irving, 1953, 1958). At Old Crow it became apparent that some of the older residents were equally sure of their recognition of the birds of their area. Illustrations, brief verbal descriptions of the appearance, attitude, action, habit, and habitat of a species brought from Joe Kay either a prompt denial of having seen the bird, or elicited complementary descriptions pertinent to the locality and season. This sort of knowledge of nature can be a most valuable aid to the scientist, for it provides him with observations made during a lifetime and in seasons and weather when most scientists remain indoors.

I obtained from Joe Kay names for all the birds that we found, except the killdeer, which was recorded only from sight, Baird's sandpiper, savannah sparrow, and Lincoln's sparrow, the specimens of which had been packed before I could ask him their names. I did not inquire about these birds, because I felt that my descriptions would not give Joe Kay a fair or reliable basis for their recognition. In addition to the species that we found he named and clearly described seven species that we did not find (Table 1).

Kay wrote the Indian names in English letters according to the scheme of writing devised by Archdeacon MacDonald for recording Anglican services for the Kutchin people. He is a man of uncommon intelligence and has long been accustomed to this form of writing, but I can neither judge its accuracy, nor correctly repeat the sounds, and I do not know the construction of the language. Joe Kay had been the elected chief of his village for 14 years (about 1920 to 1934). He is commonly called Big Joe and is often referred to as The Big Fellow, for he is renowned for his former great strength and good leadership, and for his present wisdom. I am giving the names as he wrote them, for it would be presumption for me to criticize his usage, but I must apologize for possible errors in recording.

I have been able to compare the Kutchin names for 91 species of birds at Old Crow with Eskimo names for the same species used by the people at Anaktuvuk and Kobuk, Alaska (Irving, 1958). There is a resemblance only between the Kutchin and Eskimo names for old-squaw and great grey owl. From Alaska to Greenland the Eskimo names for birds are much alike. This resemblance between names from widely separated communities demonstrates the stability of this naming process in the intellectual culture of the Eskimo people. I have no evidence for the stability of the Indian names in various regions, but the accuracy and completeness of their ability suggests that among the Old Crow Indians the naming of birds is also the result of an anciently perfected system of intellectual culture.

Arctic Indians and Eskimo have long been close neighbours. Their historians, like ours, seem to prefer to dwell upon the perversion of man's social interests by his desire for conflict rather than the relation of the stories of useful exchanges between neighbouring people, and so it is only incidentally that we learn about the implements and crafts that have been exchanged between Eskimo and Indians. Some of their ways of hunting,

fishing, and travelling are so much alike as to suggest that they recognized the practical value of each other's ways and were not averse to adopting parts of their material cultures that would adapt them better to their environment. The resemblance between two out of 91 names for birds may be accidental if it represents a conspicuous sound or appearance. Whether or not this resemblance represents an exchange of views on natural history between Eskimo and Indians, it shows how insignificant has been the exchange of non-adaptive intellectual culture. That Indian and Eskimo neighbours have a perfect and complete, but entirely different list of names for birds shows how well insulated from external influence such naming processes in intellectual culture can remain.

To those like myself, who are not familiar with unwritten languages, it is surprising to learn that a complete category of natural objects, e.g., birds, can be accurately named without the aid of a record in book or museum. The transmission of the names of objects through memory appears to be more conservative than their preservation in writing or the taxonomy of science, for the latter two processes are provisional, whereas memorized naming is definite. Upon reflection it is evident that the use of names in the transmission of knowledge by speech must be completely conservative or the result would be utter confusion.

We may also wonder what purpose was served for the old-time Indian in naming every species of bird. Only a few kinds of ducks and ptarmigan were important as food, although any sizeable bird that could be obtained was eaten, especially during times of emergency, which were not infrequent among people who had scant means of transport and storage. Birds were also used to substitute an easily acquired food for a scarce one. But in a practical way birds belong to one of the least important classes of animals. Since it is not a practical necessity, this meticulous cultivation of knowledge that is shown in the complete naming of the avifauna represents an exercise satisfying the desire of man for intellectual activity. After we began to receive explicit information about birds from the people at Old Crow, we found that their accounts were interwoven with tales of other events and experiences at the localities and times when the birds were observed. As I became better acquainted with the people, their subjective appreciation of form, colour, action, and song was often added to the signs of recognition. Later it became clear that many birds were the principal figures in delightful and often intricate stories.

These stories show that birds were one of the important natural categories used in social conversations. To make fanciful stories significant for observant people the characters and objects must possess the reality of accurate distinction by name. In dramatic representation the resemblance of reality is an essential basis for illusion and moralizing and the characters executing fanciful performances are only impressive when they have correct natural attributes.

Since distinction and naming of birds are used for social purposes, the system of naming is part of the knowledge of the community rather

than that of the individual. Much of the knowledge of the community is an inheritance that is gained by the individual through studies under the guidance of older people. In Joe Kay's case, he learned the names of birds and how to study them as part of his education while a boy. Not all the people of his age, at the time in question about 75, know birds well.

Like much knowledge in any society natural history among Indians must have been transmitted from generation to generation through the minds of a small number of individuals. This appears to us an uncertain way of preserving knowledge, for we do not trust our memories. We confidently assemble our common knowledge in libraries and museums, forgetting that history tells us of their eventual destruction by wear and tear or catastrophe and that archaeology has to show only a few fragments from which we must deduce even the commonest knowledge possessed by ancient man. We have scarcely any recollection of the stability of the stream of knowledge, which used to be transmitted verbally, and which ran intact through the minds of many successive generations, even though the channel was formed by only a few individuals.

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Table 1. Birds of Old Crow and their Indian names*.

Common loon, *Gavia immer*	Ttretetere
Arctic (Pacific) loon, *G. arctica*	Thulvit
Red-necked (Holboell's) grebe, *Podiceps grisegena*	Tekkui
Horned grebe, *P. auritus*	Notsik
Whistling swan, *Olor columbianus*	Tarui
Canada goose, *Branta canadensis*	Kyha
Black brant, *B. nigricans*	Ttsun tratesil
White-fronted goose, *Anser albifrons*	Techyo
Snow goose, *Chen hyperborea*	Kookeh
Mallard, *Anas platyrhynchos*	Natakcho
Pintail, *A. acuta*	Chinchityo & Nakostikyi
Green-winged teal, *A. carolinensis*	Tarui kahka
†Shoveller, *Spatula clypeata*	Tetrik
American widgeon (Baldpate), *Mareca americana*	Kaloree
Greater scaup, *Aythya marila*	Tani cho
Lesser scaup, *A. affinis*	Nityitin

* The common and scientific names are those of the fifth edition of the A.O.U. Check-List, 1957. Common names that have been in general use are added in ( ).

† Indian names and descriptions obtained, but no specimens seen.

Common (American) golden-eye, *Bucephala clangula*	Tovi
Barrow's golden-eye, *B. islandica*	Tesitit kyi
Old-squaw, *Clangula hyemalis*	Ahaluk
Harlequin duck, *Histrionicus histrionicus*	Tsi tut kwiluk
White-winged scoter, *Melanitta deglandi*	Nya
Surf scoter, *M. perspicillata*	Tetre la
Red-breasted merganser, *Mergus serrator*	Ttrah
Goshawk, *Accipiter gentilis*	Tzi choh
Sharp-shinned hawk, *A. striatus*	Chul rut tsit
(American) Rough-legged hawk, *Buteo lagopus*	Chut khui chun tsik
Golden eagle, *Aquila chrysaëtos*	Chittese
Bald eagle, *Haliaeetus leucocephalus*	Chizin
Marsh hawk, *Circus cyaneus*	Tzecho
Osprey, *Pandion haliaëtus*	Thuk
†Gyrfalcon, *Falco rusticolus*	Kwi tsi chi
Peregrine falcon, *F. peregrinus*	Chinechun
Pigeon hawk, *F. columbarius*	Chin tettroo
†Spruce grouse, *Canachites canadensis*	Tui
†Ruffed grouse, *Bonasa umbellus*	Chut tul
Willow ptarmigan, *Lagopus lagopus*	Taka
Rock ptarmigan, *L. mutus*	Tako
Sandhill (Little brown) crane, *Grus canadensis*	Chya
Semipalmated plover, *Charadrius semipalmatus*	Shishenetyei
Killdeer, *Ch. vociferus*	——
Common (Wilson's) snipe, *Capella gallinago*	Jazyah
Whimbrel (Hudsonian curlew), *Numenius phaeopus*	Tetnjyo
Spotted sandpiper, *Actitis macularia*	Traruk
Solitary sandpiper, *Tringa solitaria*	Tue
Lesser yellow-legs, *Totanus flavipes*	Tachoh
Pectoral sandpiper, *Erolia melanotos*	Teggetesel
Baird's sandpiper, *E. bairdii*	——
Least sandpiper, *E. minutilla*	Tagatsil
Semipalmated sandpiper, *Ereunetes pusillus*	Teggetsel ve
Northern phalarope, *Lobipes lobatus*	Trevug
Parasitic jaeger, *Stercorarius parasiticus*	Ttzel kug
Long-tailed jaeger, *St. longicaudus*	Dza
Glaucous gull, *Larus hyperboreus*	Tyittet kkya
Herring gull, *L. argentatus*	Tetyet kkya
Mew (Short-billed) gull, *L. canus*	Vyou
Bonaparte's gull, *L. philadelphia*	Chit tryo
Arctic tern, *Sterna paradisaea*	Kkya notetutgga
Great horned owl, *Bubo virginianus*	Veezay
†Snowy owl, *Nyctea scandiaca*	Riseitivay
Hawk-owl, *Surnia ulula*	Tchichitoo
Great grey owl, *Strix nebulosa*	Nastok
†Boreal (Richardson's) owl, *Aegolius funereus*	Nastotesul
Flicker, *Colaptes* sp.	Chut lut
Ladder-backed woodpecker, *Dendrocopos scalaris*	Tutchun tsya
Say's phoebe, *Sayornis saya*	Ni kut itsi
Traill's (Alder) flycatcher, *Empidonax traillii*	Sit tri gichi zzeh
Olive-sided flycatcher, *Nuttallornis borealis*	Tzivi
Horned lark, *Eremophila alpestris*	Katu
Violet-green swallow, *Tachycineta thalassina*	Ttha shait sove

——Sight record or specimens obtained, but no Indian name.

Tree swallow, *Iridoprocne bicolor*	Sha so ve
Bank swallow, *Riparia riparia*	Shai tso ve
Cliff swallow, *Petrochelidon pyrrhonota*	Shatsso
Grey (Canada) jay, *Perisoreus canadensis*	Titimkotam
Common raven, *Corvus corax*	Tatoo
Boreal (Hudsonian) chickadee, *Parus hudsonicus*	Tchichika
†Dipper, *Cinclus mexicanus*	Tsi rzui
Robin, *Turdus migratorius*	Syo
Varied thrush, *Ixoreus naevius*	Sya
Swainson's (Russet-backed) thrush, *Hylocichla ustulata*	Tzi chi tlio
Grey-cheeked thrush, *H. minima*	Tsintzio
Wheatear, *Oenanthe oenanthe*	Ttha tze
Ruby-crowned kinglet, *Regulus calendula*	Khut traluk
Water (American) pipit, *Anthus spinoletta*	Kwit kkyo zyo
Bohemian waxwing, *Bombycilla garrula*	Khut tsa luk
Northern shrike, *Lanius excubitor*	Tzi kwut go katshi lyi
Orange-crowned warbler, *Vermivora celata*	Tzi vit tich kwatlo
Yellow warbler, *Dendroica petechia*	Tsetso
Myrtle warbler, *D. coronata*	Kyekyszez
Blackpoll warbler, *D. striata*	Tzi vit sitik kwarzui
Northern (Grinnell's) water-thrush, *Seiurus noveboracensis*	Chootzi
Wilson's (Pileolated) warbler, *Wilsonia pusilla*	Tsetso khekui
Rusty blackbird, *Euphagus carolinus*	Chilly cho
Pine grosbeak, *Pinicola enucleator*	Teevay
Redpoll, *Acanthis* sp.	Taloo
White-winged crossbill, *Loxia leucoptera*	Tizinkee
Savannah sparrow, *Passerculus sandwichensis*	——
Slate-colored junco, *Junco hyemalis*	Tchikikeekeejay
Tree sparrow, *Spizella arborea*	Tchinkee
(Gambel's) White-crowned sparrow, *Zonotrichia leucophrys*	Natzik
Fox sparrow, *Passerella iliaca*	Tcheekeekek
Lincoln's sparrow, *Melospiza lincolnii*	——
Lapland (Alaska) longspur, *Calcarius lapponicus*	Shinjee
Snow-bunting, *Plectrophenax nivalis*	Kukuzu
Total number 103	99

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NORTHERN NEWS

The Kayakers of Igdlorssuit*

"Dr. H. I. Drever, of the University, will spend a lonely summer in an open boat with an outboard motor in the waters around northern Greenland."

From this statement in a local paper it would certainly seem that I went this time to Greenland alone. Alone I was indeed, if not in the sense implied, and I travelled far in knowledge of the profoundly interesting geology of Ubekendt Ejland. I travelled further, I think, in understanding the people who stay here in a village called Igdlorssuit.† It is of them I should like to try to write on this occasion.

From the villagers' point of view I arrived last summer right out of the blue. I was welcomed as a sort of beneficient uncle who was known (like the men who came with me) to have a special talent for doing incomprehensible and sometimes difficult things, and getting away with it. No doubt it was a surprise to find I was alone this time, but the sight of the usual supply of strong scotch ale immediately dispelled the initial impression that I must have come down in the world.

In circumstances such as those in which I found myself, a European has many advantages — in background, experience, much higher living standards, comparative wealth, and so on. Willingly or unwillingly he inevitably becomes a big fish in a little pool. If he realises this, and also that the little fish are more than a little sensitive about what appears to be their relative stature, he will enjoy their abundant sociability and discover in time that some of them on any reckoning are men and women of very real calibre.

As soon as possible I think he should make it quite clear that he respects native integrity both in the Greenlanders and in himself and that he is unimpressed by cheap imitations. The loss of native integrity that one meets so often in many parts of Greenland is perhaps, as it is in our colonies, the saddest feature. It is just as pathetic to see a Greenlander trying to be a European as it would be to see a European try to be a Greenlander. There is doubtless nothing new about this attitude toward ethnological and cultural realities. I can at least confirm from my own experience that once my attitude was clearly defined, it was understood and appreciated.

During two summer months only a fraction of an inch of rain fell and the sky was full of colour day and night. The sun swung round and round and never set, successively burnishing all sides of the mountains, glaciers and icebergs, and continuously illuminating the sea. Toward this sea all houses are turned and over it many eyes are constantly scanning and watching. Its life at one time fully sustained the life of the village in natural rhythm and equilibrium. Now the villagers partly depend for their welfare on Danish social and economic services and could neither continue to exist without these nor would wish to if they could. Their economy is still to a very large extent based on seal-hunting in kayaks during the summer

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† Eskimo settlement on Ubekendt Ejland (Unknown Island), a small island in Umanak Fjord, north of Disko Island, on the west coast of Greenland, where the author worked intermittently from 1938 to 1957.

Young Greenlanders and their Eskimo grandfather, who, at 79, was the oldest villager in Igdlorssuit when the pictures were taken in 1957.

and dog-sledges in spring. The art of kayaking has been mastered by very few Europeans, the most notable being the British explorer, Gino Watkins.

When I was a student, Watkins represented to me a far more significant figure than any professor, apart from my father. There seemed to be many professors but only one Watkins. Although later on I found that I was a curable romantic my respect for him remained. It is now twenty years since an Eskimo from Thule first lent me his kayak and jammed me into it, and all I can remember of this ordeal is that I was very much relieved that I did not overturn and very glad to get out. The next summer, having spent some of my time in Igdlorssuit practising the management of a kayak, I discovered among other things that it could be used quite effectively for geological reconnaissance work on coastal cliffs. After a foolhardy journey of eighteen miles alone had nearly cost me my life, I decided to learn how to right myself after overturning. This I was able to do the following winter in St. Andrews harbour in a kayak I had brought home from Igdlorssuit. But I

have never mastered the technique of seal-hunting.

The Greenland kayak, although very manoeuvrable and efficient, is at the same time so absurdly small and frail that to chase a seal in it seems almost an impertinence. The contempt that no doubt the seal must feel on seeing a kayak usually coincides with the swift arrival of a harpoon thrown with unerring accuracy at the base of its neck. But that is not always the end of the hunt; it is sometimes the end of the hunter. Very few families in Igdlorssuit have not lost a father, a brother or a son by drowning during a seal's last frantic fight for its life.

Were you to imagine yourself sitting beside my camp about nine o'clock one morning you would see first one kayaker (Enoch) move out from the far end of the village over the clear bluish-green sea. Then quickly in succession two from the centre (Otto and Algot) and another near you (Tobias). Five minutes later the minister carries down to the shore the new kayak he completed last night. They all fan out and diminish rapidly to distant dots and disappear in the direction of the mountains, glaciers and great masses of ice at the entrance to one of the fiords that lead to the ice cap. Two other hunters have set off earlier.

The rest of the village activities continue throughout the day. The shark lines have to be visited in the small home-made dories or in larger boats up to 16 or 17 feet long bought from the Danish Trading Company. The children catch cod in the bay. The geologist roars off in a 14-foot long, outboard-powered, dinghy with two assistants. They are happy to be with him so long as it is reasonably remunerative and adventurous. Seals are very scarce within twelve miles from the village on most summer days and the surer income is attractive.

About five o'clock one kayaker is located through a telescope and the way he is paddling interpreted without hesitation. He has a seal, but fully half an hour will elapse before his identity can be established. Then another is seen with no seal. By the time he reaches home he may have travelled between thirty and forty miles. Suddenly two kayaks are spotted near the shore north of the bay, moving very slowly. This means no more or less than a big bladder-nose seal as long as the kayak, heavy and dangerous, but with a £5 skin and plenty of good meat. Luckily another kayaker has been near enough to help bring it back. Four huskies are despatched along the two miles of sandy beach. They know their job and soon come trotting back gaily dragging the two kayaks and the seal behind them. The successful kayaker — it is Ludwig — strolls nonchalantly, with hands in his pockets, alongside; the other, still in his kayak, steers. This is a grandstand finish with the villagers watching at their doors, silently acclaiming it. Not until nine o'clock is the minister seen moving slowly homeward in the slanting sunlight. By this time the villagers have eaten as much as they want of seal meat: some of it raw, as they have no other source of vitamin A. The geologist and his two assistants have eaten their share and will get more from the minister tomorrow. There is no payment.

The minister, a Greenlander and one of the ablest translators of Danish into Eskimo in north-west Greenland, helped me organise a Sunday afternoon sports meeting. Among items on the agenda there were beauty competitions (women and men) and shooting at empty beer bottles, but the two kayaking events were, I think, the highlights. I decided to try to inaugurate an aquatic sports meeting later on when all the crack seal-hunters were in the village, and it is more appropriate to describe this second occasion though kayak-rolling had then to be excluded.

Eight fully equipped kayaks lined up at the starting point opposite the village store. Abraham, the headman, fired the starting gun and off they went on a two-mile course, at a speed of about 5½ knots across the bay beyond my camp and back again. The minister was umpire. Ludwig, a thickset tough teetotaller, came in first — his prize a hurricane lamp bought in St. Andrews. Enoch was second, two lengths behind, with his elder brother the same distance behind him.

At the end of a rope behind my dinghy I had attached a sack tightly packed with straw. I now set out with this homespun seal, lined the kayakers up and at full-throttle roared past them at about 6½ knots. My seal reached the end of the line with all eight harpoons buried deeply in its flanks. This item went down very well — so well, in fact, that I decided there and then to offer a trophy for annual competition to the kayakers of Igdlorssuit.

Perhaps it would not be amiss to add here one or two of my reflections on the Greenlanders and their future. Before doing so I must hasten to admit that I am only a "summer man" — an expression coined needless to say by "winter men" — and with them my opinion may not, almost literally, cut any ice. And I have a pitifully inadequate knowledge of the Eskimo language, a deficiency I share incidentally with most "winter men." Any advantage I possess lies in the fact that since 1938 I have stayed in the same village four times, constituting in all a period of almost one year over a span of nineteen. Not many people have had such a privilege. No one else has had it in Igdlorssuit.

The villagers of Igdlorssuit no doubt have much in common with isolated village communities in other parts of the world. Many of their problems are thus universal; but some are more strictly attributable to their arctic environment, to which they are either tending to lose or have actually lost their traditional adaptation.[1]

How much of their cultural heritage will remain as they become more and more Europeanised? Will they flourish or decline? How can they achieve, without loss of indigenous values and integrity, a higher culture and a living standard equal to that of villagers in Europe? Frankly, I do not know; and I have yet to meet someone who does. What an academic geologist like myself can contribute is only a few facts which have attracted — or perhaps distracted — his attention, and an opinion based on these facts. I now know enough about West Greenland to be convinced that the Danes, in spite of special difficulties, hardships and hazards, have done and are doing a very fine job. It might even be said that they have done too much for Greenland. This means among other things that they can afford to be critical of their own administrative policies and are unlikely to resent criticism from any outsider. These policies may result in a rising export trade but it is salutary to recall that this from a philosophical standpoint "does not always prove a colony is making progress; it may also mean that it is on the way to ruin."[2]

I do not wish to undervalue the importance of my own subject, and I am not unaware of practical economic realities in Greenland. But if anyone asserted that social anthropologists were more important than geologists to the future of Greenland I must confess I should be inclined to agree. I am unable to subscribe to a concept of progress simply in terms of economic expediency, ballot boxes or mass assimilation of most of the Greenland population that may eventually lead to a complete evacuation of such villages as Igdlorssuit. As a remedy for Greenland's growing pains it is as ancient as alchemy and a counsel of despair. Danes I have met who have an intimate knowledge of the traditional way of life would welcome a clearly defined, step-by-step, policy of sociological adjustment empirically and imaginatively conceived and directed on a purely cultural level. An experiment of this kind is still possible in the few backwaters which the flood of Europeanisation has flowed mercifully past. Igdlorssuit is one of these and I left it convinced that here, and in places like it, there is fertile soil from which the growth of mutual understanding between individuals of vastly different background would be only a matter of thought, language and time.

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[1] The status of seal-hunting in kayaks is rapidly declining in West Greenland, but the Danish administration has in some places sponsored training in kayaking for native children.

[2] Albert Schweitzer: My Life and Thought. Greenland is now no longer a colony; it was integrated in Denmark in 1953.

In addition to qualified anthropologists there are many people who have insight and interest enough to detect true values in the indigenous cultural patterns of primitive communities. Their cultural and economic advancement almost invariably is accompanied by the loss of these values, by disruption rather than adjustment. And the results of ethnographical surveys among primitive communities may exercise but little influence on major administrative policies. If there is a solution to this problem in West Greenland it will demand more than authoritative advice from specialists operating ineffectually on the side-lines of the administration.

Of all my summers in Greenland, I think this "lonely summer in an open boat" was my happiest. For if loneliness is to be surrounded by indifference, distrust or illwill I could count myself about the least lonely geologist who has ever set out to do his field work alone.

H. I. Drever

GEOGRAPHICAL NAMES IN THE CANADIAN NORTH

The Canadian Board on Geographical Names has adopted the following names and name changes for official use in the Northwest Territories and Yukon Territory. For convenience of reference the names are listed according to the maps on which they appear. The latitudes and longitudes given are approximate only.

Abitau Lake, 75B
(Adopted June 6, 1957)

Bouvier Bay	60°06′N	106°17′W
Glass Lake	60°07′	106°45′
Carleton Lake	60°17′	106°57′
Tite Lake	60°32′	107°18′
Geeves Lake	60°52′	107°15′

Dahadinni, 95N
(Adopted June 6, 1957)

Canyon Ranges	63°35′N	125°30′W
Mackenzie Plain	63°30′	124°30′

Wholdaia Lake, 75 SE
(Adopted June 6, 1957)

Knobovitch Lake	61°07′N	106°50′W
Mansfield Lake	61°06′	107°17′
Cronyn Lake	61°28′	107°02′
Burpee Lake	61°28′	106°40′
Donnelly Lake	61°34′	106°24′
McArthur Lake	61°35′	106°50′
Miller Lake	61°38′	107°13′
Lamarre Lake	61°55′	107°08′
Moss Lake	60°23′	106°10′

Borden Island, 89 NE and 79 N ½
(Adopted June 6, 1957)
Altered application

Deer Bay	78°45′N	104°15′W

Chart 6374, Approaches to Tuktoyaktuk Harbour
(Adopted June 6, 1957)

Whitefish (locality)	69°23′N	133°37′W
Canyanek (locality)	69°24′	133°21′
Peninsula Point	69°24′	133°12′
Lousy Point	69°14′	134°13′
Triple Summit (hill)	69°32′	132°54′
Shore Summit (hill)	69°32′	132°58′
Whitefish Summit (hill)	69°24′	133°32′
Stick Summit (hill)	69°30′	132°58′

Bare Summit (hill)	69°29′	132°58′	
Holmes Creek	69°12′	134°11′	
Name confirmation			
Eskimo (Husky) Lakes	69°13′	132°25′	not Husky Lakes nor Eskimo Lakes
(Adopted October 3, 1957)			
Altered applications			
James Shoal	69°43′N	132°55′W	
Split Hill	69°24′	133°06′	
Crater Summit (hill)	69°24′	133°06′	

Chart 5450, Hudson Strait
(Adopted June 6, 1957)

Reversing Falls	62°24′N	69°02′W	
Northeast Cliff	60°35′	68°00′	
Scree Point	60°24′	67°52′	
Southeast Point	60°18′	67°58′	
Hettash Island	60°30′	64°54′	
Low Islands	59°32′	69°34′	
Alle Reefs	59°22′	69°44′	
Nanertak Reefs	59°12′	69°12′	
Ivugivik Harbour	62°25′	77°56′	
Terreoukchuk Bay	64°32′	75°34′	not Terreookchuk (bay) nor Terreookchuk Bay nor Terreoukchuk (bay)
Keltie Inlet	64°24′	73°30′	not Keltie Bay
Altered applications			
Glasgow Inlet	62°49′	69°48′	
Upper Savage Islands	62°36′	69°56′	
Name confirmation			
Westbourne Bay	62°48′	69°48′	

Ethel Lake, 115 P/8
(Adopted June 6, 1957)

Twentyone Mile (locality)	63°26′N	136°23′W	
Ghechuck Lake	63°27′	136°15′	
Ghechuck Creek	63°28′	136°17′	
Rusty Creek	63°27′	136°27′	
McGuinty Creek	63°29′	136°22′	
Ethel Lake Gap	63°25′	136°13′	
U Slough	63°27′	136°21′	
Tresidder Lake	63°28′	136°14′	
Twentysix Mile (locality)	63°24′	136°28′	not Twentysix Mile Landing
Sether Creek	63°22′	136°10′	not Johnston Creek
Altered application			
Tresidder Creek	63°29′	136°14′	

Dawson, 116 B/3
(Adopted June 6, 1957)

Arlington (settlement)	64°02′N	139°10′W	
Lovett Hill	64°02′	139°21′	
Dago Hill	64°01′	139°07′	
Preido Hill	64°00′	139°06′	
Noble Creek	64°10′	139°15′	
Pepin Creek	64°09′	139°13′	
Benson Creek	64°05′	139°27′	
Dawson Creek	64°04′	139°27′	
Dago Gulch	64°02′	139°11′	
Tinhorn Gulch	64°00′	139°03′	
Eighty Pup (stream)	64°01′	139°05′	not 80 Pup (stream)
Sawmill Gulch	64°01′	139°29′	not Sawmill Creek
Seventy Seven Pup (stream)	64°00′	139°22′	not 77 Pup (stream)
Eight Pup (stream)	64°00′	139°09′	not 8 below Pup (stream) nor Discovery Pup (stream)

Dawson, 116B and 116C (E ½)
(Adopted July 4, 1957)

Additional name			
North Fork Pass	64°33′N	138°15′W	not North Klondike Pass

(Adopted December 5, 1957)

Maiden Creek	64°23′N	140°38′W	
Name changes			
Mickey Creek	64°23′	140°37′	not Browns Creek
Gates Creek	64°19′	140°52′	not Browns Creek
Altered application			
Bruin Creek	64°21′	140°46′	not Bear Creek

Cumberland Sound, 26 SW and 26 SE
(Adopted July 4, 1957)

Name changes			
Ivisa Island	65°58′N	67°07′W	not Kekertar Island
Auniakvik Bay	65°54′	67°22′	not Audnerbing Bay
Kekertukdjuak Island	65°51′	65°36′	not Kekertuk Island
Ujuktuk Fiord	65°17′	64°22′	not Ugjuktung Fiord

Netilling Lake, 26 NW and 26 NE
(Adopted July 4, 1957)

Name changes			
Shilmilik Bay	66°35′N	67°22′W	not Sirmilling Bay
Usualuk Mountain	66°17′	66°28′	not Usualung Mountain
Iglunga (settlement)	66°17′	67°07′	not Iglungayut (settlement)
(Adopted August 1, 1957)			
Name confirmation			
Clearwater Fiord	66°33′N	67°30′W	not Isuitok Fiord

Chart 5579, Brevoort Harbour
(Adopted July 4, 1957)

Labrador Head	63°19′N	64°10′W	
Brevoort Harbour	63°18′	64°08′	
Saddleback Point	63°18′	64°08′	
The Needle (hill)	63°17′	64°07′	
Pullen Point	63°18′	64°10′	not Grant Point
Asiak Rock	63°19′	64°10′	not Asiaq Rock
Altered application			
Cape Murchison	63°17′	64°07′	

Seattle Creek, 115 P/16
(Adopted August 1, 1957)

Flet Creek	63°59′N	136°20′W	
Goodman Creek	63°54′	136°09′	
Rodin Creek	63°52′	136°17′	
Sabbath Creek	63°47′	136°21′	
Morrison Creek	63°50′	136°06′	
McRae Creek	63°46′	136°11′	
Dredge Creek	63°45′	136°09′	
Scheelite Gulch	63°47′	136°17′	
Swede Gulch	63°47′	136°15′	
Harvey Gulch	63°46′	136°14′	
Strike Gulch	63°49′	136°16′	
Scheelite Dome	63°48′	136°15′	
Oliver Creek	63°47′	136°32′	
Laska Gulch	63°49′	136°19′	
Minton Creek	63°47′	136°21′	
Savage Gulch	63°48′	136°18′	
Ortell's Crossing (ford)	63°49′	136°23′	
Castnor Creek	63°50′	136°20′	not Cement Creek
Rudolph Gulch	63°46′	136°11′	not Rudolph Creek
Deletion			
Ortell Cabin (locality)	63°49′	136°23′	

King William Island, 67 SW and 67 SE
(Adopted October 3, 1957)

Sophia Island	69°38′N	96°53′W	
Altered applications			
Cape Edgeworth	69°21′	96°13′	
Gladman Point	68°40′	97°48′	

Port Brabant, 107 SW and 107 SE
(Adopted September 5, 1957)

Lost Reindeer Lakes	68°07′N	132°25′W	
North Caribou Lake	68°46′	132°43′	
Dolomite Lake	68°18′	133°32′	
Owen Lakes	68°28′	132°10′	
Williams Lake	68°33′	132°14′	
Shelter Creek	68°41′	133°04′	
Noell Lake	68°32′	133°33′	
Face Point	68°51′	132°57′	
Bonnieville Point	68°51′	133°25′	
Kalinek Channel	68°07′	134°10′	
Old Man Lake	68°58′	132°16′	
Canoe Lake	68°08′	135°54′	
Axel Creek	68°40′	134°38′	
Leland Channel	68°32′	135°25′	
Reindeer Channel	68°53′	135°05′	
Wolverine Lakes	68°52′	134°10′	
Neklek Channel	68°58′	134°43′	
Gull River	68°11′	133°48′	
Norris Creek	68°23′	132°58′	
Cache Creek	68°30′	135°48′	
Myers Lake	68°27′	135°16′	
(Adopted November 7, 1957)			
Twin Lakes	69°42′N	128°55′W	
The Hook (spit)	69°42′	129°02′	
Snow Goose Knoll (hill)	69°41′	129°02′	
Gull Islets	69°45′	128°58′	
Eagle Bluff	69°42′	128°57′	
Landfall Lake	69°43′	128°55′	
South Flat Island	69°42′	128°59′	
Delta Islets	69°41′	128°57′	
West Channel	69°42′	129°00′	
North Flat Island	69°44′	129°00′	
Triangle Island	69°43′	129°05′	
Main Channel	69°42′	128°58′	
Snow Goose Creek	69°42′	129°05′	
Old Stanton Lake	69°45′	128°48′	
Caribou Island	69°42′	128°57′	
Swan Lagoon	69°43′	128°58′	
Castle Bluff	69°47′	128°46′	not Fort Bluff
East Bluff	69°43′	128°58′	not West Bluff
Tingmiak Lake	69°41′	128°57′	not White-Front Lake nor Goose Lake
Loon Lake	69°59′	128°20′	not Pacific Loon Lake
Krekovik Landing (landing)	69°42′	128°58′	not Schooner Landing (landing)
Niarkrok Harbour	69°50′	129°00′	not Knoll Harbour

Wellington Channel, 58 NW and 58 NE
(Adopted September 5, 1957)

Abbott River	75°17′N	95°57′W	
Ellis Creek	75°16′	95°57′	
Ward River	74°52′	95°43′	
Taylor River	74°50′	95°31′	
Bacon River	74°53′	94°48′	
Allen River	74°49′	95°15′	
Goodsir Creek	74°50′	93°20′	
May Island	74°45′	95°07′	
Marshall River	74°40′	94°15′	
Trafalgar Lakes	74°42′	94°20′	
Cape Dungeness	74°39′	93°40′	
Mecham River	74°42′	94°49′	
Pullen Strait	75°32′	95°53′	
Prospect Hills	74°42′	94°10′	
Name confirmations			
Eleanor Lake	75°24′	93°55′	
Read Bay	75°04′	93°35′	not Kane Bay
Altered application			
Kate Austin Lake	74°42′	94°18′	

Chart 6372, Tuktoyaktuk Harbour
(Adopted October 3, 1957)

St. Roch Island	69°27′N	132°59′W	
Kiktoreak Point	69°26′	132°58′	
Cache Point	69°26′	133°00′	
Saviktok Point	69°25′	132°58′	
Tern Island	69°24′	133°00′	
Nallok Point	69°25′	132°59′	
Kriterk Point	69°24′	132°58′	
Malrok Point	69°24′	132°58′	
Reindeer Point	69°23′	133°00′	
Aveltkok Inlet	69°27′	132°58′	
Fresh Water Creek	69°26′	132°58′	
Pikiolik Lake	69°27′	132°56′	
Ice Lake	69°26′	133°02′	
Mayogiak Inlet	69°25′	132°57′	
Fort Ross Islands	69°26′	133°00′	not Ross Islands
Fort Hearne Island	69°26′	132°59′	not Hearne Island

Barrow Strait West, 68 NW and 68 NE
(Adopted September 5, 1957)

Coal River	75°03′N	96°05′W	
Bond Point	75°18′	96°10′	
Templeton Bay	75°32′	96°30′	
Name changes			
Little Cornwallis Island	75°32′	96°30′	not Hubbard Island
Midshipman Bay	75°16′	96°08′	not Daniels Harbour nor Markham Bay
Graham Bay	75°12′	96°24′	not Fiske Harbour
Marshall Peninsula	75°26′	96°05′	not Matthews Peninsula

Frobisher Bay, 25 NW and 25 NE
(Adopted October 3, 1957)

Meta Incognita Peninsula	62°45′N	68°30′W	not Kingait Peninsula

Chart 5580, Loks Land to Brevoort Island
(Adopted October 3, 1957)

Enchantress Island	63°17′N	64°46′W	
Sarah Island	63°12′	64°34′	
Pseudo Bear Island	62°22′	64°28′	
Morris Island	62°26′	64°19′	
Cape Hayes	62°34′	64°08′	
Castle Bay	63°03′	64°48′	
Singeyer Pass	62°55′	64°53′	
Sylvia Island	62°34′	64°47′	
Sterry Tower Island	63°13′	64°33′	not Sterry Tower (island) nor Sugarloaf (island)
Cape Melby	62°47′	65°03′	not Melby Cape
Tagliabue Island	62°20′	64°37′	not Tagbabue (Tagliabue Island) nor Tagbabue Island
Kittridge Island	64°20′	64°35′	not Kittredge Island
Queen Elizabeth Foreland (cape)	62°23′	64°28′	not North Foreland (Queen Elizabeth Foreland)
Mount Buddington	62°54′	64°53′	not Buddington Mountain
Mount Dillon	62°32′	64°23′	not Dillon Mountain nor Dillon Mount
Ebierbing Bay	63°15′	65°00′	not Ebienbing Bay nor E-Bien-Bing Bay
Tookoolito Inlet	63°05′	64°50′	not Tuhulitas Inlet
Altered applications			
Lefferts Island	62°30′	65°03′	
Beare Sound	62°30′	65°02′	
North Foreland (cape)	62°32′	64°07′	

Bea Lake, 85 N/10
(Adopted November 7, 1957)

Wonnacott Lake	63°43′N	116°41′W	
Cole Lake	63°40′	116°36′	

Crow Foot Lake	63°37′	116°34′	
Dennis Lake	63°37′	116°43′	
Hump Lake	63°35′	116°33′	
Lou Lake	63°34′	116°47′	
Betty Ray Lake	63°32′	116°34′	
Burke Lake	63°31′	116°43′	

Amundsen Gulf, 97 NW and 97 NE
(Adopted November 7, 1957)

Whale Bluffs	70°20′N	127°22′W	
Ikpisugyuk Point	70°10′	128°10′	
North Star Harbour	70°15′	127°40′	not Wolki's Inlet nor North Star Inlet
Altered application			
Maitland Point	70°09′	128°20′	

Nadaleen River, 106C
(Adopted November 7, 1957)

Bonnet Plume Range	64°45′N	133°00′W
Algae Mountains	64°34′	133°42′
Pass Mountain	64°31′	133°38′
Rackla Range	64°30′	133°35′
Salutation Peak	64°29′	133°50′
Rusty Mountain	64°18′	133°44′
Nadaleen Range	64°10′	133°10′
Nadaleen Mountain	64°15′	133°03′
Goz Pass	64°33′	132°20′
Rackla Pass	64°30′	133°39′
Fairchild Lake	64°58′	133°47′
Goz Lake	64°32′	132°20′
Rackla Lake	64°18′	133°15′
Duo Lake	64°29′	132°07′
Ortell Lake	64°03′	132°51′
Gillespie Creek	64°46′	133°43′
Pinguicula Creek	64°37′	133°35′
Corn Creek	64°39′	133°33′
Hematite Creek	64°38′	133°22′
Black Canyon Creek	64°38′	133°21′
Reptile Creek	64°34′	132°14′
North Rackla River	64°22′	133°49′
Salutation Creek	64°28′	133°48′
Rubble Creek	64°29′	133°29′
Kohse Creek	64°32′	133°27′
Goz Creek	64°22′	132°45′
Duo Creek	64°24′	132°32′
East Rackla River	64°15′	134°00′

Nash Creek, 106D
(Adopted December 5, 1957)

Altered Application		
Mount Braine	64°32′N	134°21′W